The Relationship Between Self-Prioritization, Reward-Prioritization and Emotion-Prioritization Effects; an EEG Study

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Abstract

Human behaviour is biased in many ways. Three key influential factors that affect the way we prioritise our behaviour (even at a perceptual level), are high-reward, self-relevance and positive-emotions. Literature surrounding these perceptual drivers, yields inconsistent evidence towards the relationship between them (Björn, Moritz de, Ulrike, Claus, & Georg, 2009) ;Yankouskaya et al., (2018). The current study used a novel approach to investigate the relationship between basic effects of self-reference, reward and emotion on perception. Nineteen adults, (eleven females) between 18 and 38 years old, participated in three variants of an associative-matching-task from Sui, He, & Humphreys, (2012). Whereby participants learnt shape-label matches between; self or stranger, £8 or £2 and happy or neutral labels, in addition we recorded EEG from 64 electrodes to measure electrophysiological responses toward the stimuli. Event related potentials (ERPs) were analysed for P1, N1, P2, N2 and P3 components. Shape-label matches for self compared with stranger labels evoked a significant decrease in posterior P2 amplitudes (223ms) and a significantly greater amplitude of P300 (336ms) for self-relevant stimuli. We found a significantly stronger magnitude in P1 and posterior P2 effects for low-saliency stimuli (stranger) compared with high-saliency (self), and for self-relevance and positive emotion compared with high reward. We found a significant moderate negative relationship for anterior P2 amplitudes, and a significant moderate positive relationship for posterior P2 effects between self- and reward-prioritization effects. However no significant relationship was found between these and emotion- prioritization effects Thus, the time courses for self emerges slightly earlier than emotion and reward, but they share similarities in time courses in later processing, which indicates that the self is highly prioritized and plays a modulatory role between emotion- and reward-processing. Findings have implications in many areas including clinical research, for example refining successful treatment and diagnosis of disorders whereby individuals have reduced functioning of self and emotion- processing, such as depression and anxiety.

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1.0. Introduction

The constant challenge of deciphering the vast stimuli from the world, is an area that has been explored for many years (Cherry, 1953; Handy & Kam, 2015; Moore & Egeth, 1997). Owing to limitations within processing capacity it is necessary to prioritize information considered relevant and inhibit any distractors (Tsotsos, 2017). Consistent findings have shown that the process of perception is influenced and guided by the attended stimuli, which in turn can facilitate behaviour (Eysenck & Keane, 2002; Sui, Yankouskaya, & Humphreys, 2015). There are many biases surrounding perception which question factors that mediate the use of limited resources to perceive an attended stimulus (Humphreys & Sui, 2015).

Moreover even when attentional resources are not limited prioritization of one stimuli over another can occur i.e. high- over low-reward (Sui & Humphreys, 2015). This hierarchical focus towards certain stimuli might serve to promote fitness and thus be evolutionary advantageous, in that stimuli most relevant towards survival success (i.e. high-reward) requires a rapid response and is therefore prioritized (Anderson, 2016; Brosch, Pourtois, & Sander, 2010). Amongst the various stimuli that can attract a persons' attention the current research focuses on the perceptual biases surrounding information related to self, reward and emotion and considers the relationship between them.

1.1 Self-prioritization effects

Self-prioritization is a function that guides our attention towards self-relevant information (as opposed to non-self-relevant), making it something that is hard to consciously ignore (Frings, 2006). An example of self-relevant stimuli is one's own name, exhibited in a classic study of selective attention using a scenario of a noisy party (Cherry, 1953). Findings

highlight the ability to focus on a conversation through suppression of background noise (the unattended channel), which in turn leads to a lack of recall for the suppressed noise.

However, if one's own name is mentioned in the unattended channel it has been shown that attention is automatically diverted to the source (Moray, 1959). Thus, demonstrating that self-relevance seems to effect attentional responses in an exclusive manner. Self-focused attention can also be defined as an excess awareness of one's behaviour (Ingram, 1990), considered to hold evolutionary benefits, in that self-relevance holds a direct significance to our well-being and survival and therefor requires a rapid response (Focquaert, Braeckman, & Platek, 2008).

Advantages in memory have been demonstrated via increase in recall performance for encoded self-focused stimuli (Kelley et al., 2002). This encoding advantage is known as the self-reference effect (SRE) (Rogers, Kuiper, & Kirker, 1977). There are many explanations as to why self-prioritization occurs in memory, one is that the self is an exclusive cognitive structure which has extra mnemonic capacity (Symons & Johnson, 1997). Supported by neuroimaging studies, for example, fMRI evidence shows unique activation for self-related-stimuli in areas supporting attentional- and reward-processing, (such as posterior dorsomedial prefrontal cortex and supramarginal gyri), and activation of these areas correlated with the magnitude in memorial advantages of self-related-stimuli (Turk, van Bussel, Waiter, & Macrae, 2011).

An alternative explanation for the advantages of self-prioritization in memory explains that there are no extra special abilities that the self has, and that the extra memorability is due to the extension of the basic depth-of-processing effect caused by familiarity of the self (Bellezza & Hoyt, 1992; Kihlstrom et al., 1988). There has also been conflicting evidence that the self has no better memorability and recall than another familiar

person (Greenwald & Banaji, 1989). Hence, the disagreement within the literature and the inconsistencies in theoretical understanding of self-prioritization effects.

In other respects, self-prioritization also affects human perception (Sui, Liu, Wang, & Han, 2009). This is demonstrated by Sui et al., (2012), using an associative matching paradigm. Whereby participants developed mental associations of self, friend and other with arbitrary shapes and were asked to match correct pairings of the given associations in a perceptual decision task. Results indicated a significant effect in reaction times for self-associated stimuli in that participants were faster and more accurate in responding to them compared to non-self-stimuli. An extension by Sui, Rotshtein, and Humphreys, (2013), examined fMRI activation during judgments of the associated matching task, revealed that self-matched pairs had a stronger activation compared to friend/other, in the left-lateral posterior temporal sulcus and ventromedial prefrontal cortex (vmPFC), activation in these areas were shown to be a predictor for the SRE. Findings indicate that self-associated stimuli modulate perceptive responses and suggests an existence of a "Self-Attention Network" that can enhance cognitive function.

Incidentally, the use of arbitrary shapes to examine self-prioritization also somewhat goes against critical explanations of familiarity effects of self-related stimuli. A study by Wade and Vickery, (2017), expanded Sui et al.'s (2012), associative-matching paradigm to investigate if self-relevance is the reason for enhancement of performance or whether there are other causes such as threat and concreteness. Findings revealed that self-relevant labels were significantly more accurate and faster in all trials. This effect also remained with reduced frequency in occurrence of self-related-stimuli, indicating an automaticity in self-relevant processing in an exclusive manner (Sui, Sun, Peng, & Humphreys, 2014). Attempts to localize the source of the SRE process suggest that it seems to occur at the central capacity limited stage of processing (Janczyk, Humphreys, & Sui, 2018).

The surrounding literature indicates that the self seems to influence perception, in that visual and auditory self-relevant stimuli seems to modulate an exclusive perceptual process that generates more accurate and faster responses (Rogers et al., 1977; Sui et al., 2014). The relationship between personal relevance and behavioural performance appears to be linear (Yankouskaya, Bührle, Lugt, Stolte, & Sui, 2018).

1.2 Reward-prioritization effects

The two terms reward-bias and reward-prioritization are synonymous for the perceptual influence of rewards on behaviour. Different rewards can have different effects on human behaviour (Gottfried, 2011). In a similar fashion to self-prioritization, reward-prioritization effects reflect biased responding to different reward values, in that people tend to respond more accurately and faster to stimuli associated with high reward, for example, this was demonstrated by Sui et al's., (2012), associative matching task. Participants were shown reward associations to arbitrary shapes (e.g., circle-£9, square-£4, triangle-£1), following which they completed a matching task where they had to indicate if shape-label pairings were correct/incorrect. Findings revealed that higher rewards were shown to modulate faster reaction times and improve accuracy of performance (which degraded in accordance to monetary values), indicating a biased response to high rewards.

Furthermore, oculomotor response suggest that the salience of visual stimuli is altered when associated with high rewards, in that they become more prominent over low rewards, for example, the examination by Theeuwes and Belopolsky, (2012), of eye movements during visual tasks using monetary rewards, showed saccadic reactions were faster for high rewards compared to low. Findings showed an overall main effect for rewards on attention contrary to goal-directed behaviour. This therefore suggests that reward-prioritization may be an automatic response. Neurological evidence has also linked mesolimbic dopamine as a

contributing factor to the underlying atomicity in reward perception (Alcaro, Huber, & Panksepp, 2007). In addition, activity in the anterior cingulate cortex (an area with strong dopaminergic connections), has been shown to be a predictor for the magnitude of reward-prioritization (Hickey, Chelazzi, & Theeuwes, 2010).

However, several studies have reported that there is no strict linear relationship between reward value and behavioural performance, for example Yankouskaya et al., (2018), adopted an associative matching paradigm from Sui et al., (2012), but increased reward associations to a five-item procedure (£9, £7, £5, £3 and £1). Interestingly results reported a u-shaped curve for reward values, in that reaction times were faster for highest (£9) and lowest values (£1). Findings indicate memory implications surrounding reward processing, in that it is not the value of the reward itself, but the increased salience produced by the extremes of the rewards (largest gains and the largest losses) that enhances memory (Madan & Spetch, 2012). Research has also linked the memory bias for rewards to decision making (Madan, Ludvig, & Spetch, 2014). Therefore, studies using the same paradigm may not have found similar effects due to smaller differences between reward values.

The literature indicates that there is a perceptual influence of reward on behavioural performance, in that the salience of rewards is dependent on the value, and the relationship between reward values and behavioural performance is not linear (Yankouskaya et al., 2018).

1.3 Emotion-prioritization effects

Emotion-prioritization effects reflect a biased response to emotional content, in that emotional stimuli are considered to have higher relevance and therefore takes prioritization over neutral stimuli (Sawada & Sato, 2015; Vuilleumier, Armony, Driver, & Dolan, 2001). An example of emotional stimuli are faces, as used by Sawada and Sato, (2015), who found

that photographs of faces with either an emotional (happy/angry) modulated attentional responses compared to neutral expressions.

The current research focuses on the effects of happy and sad emotions. The main reason for choosing these two expressions is that there is inconsistency regarding the effects of fearful, disgust and surprise emotions in faces (these emotions are complex, and people often confuse and misinterpret these emotional expressions) (Wilson, 2008). Moreover, fearful faces may facilitate response time and there is no agreement on the differences in behavioural responses to happy faces versus fearful faces (Gray, Adams, Hedger, Newton, & Garner, 2013).

Emotion-prioritization effects are reflective in response times and accuracy of performance, for example Bucher and Voss, (2018), examined the perceptual valence of emotions by recording participant gaze of photographs and computer generated faces with happy, angry or neutral expressions. Results indicated a prioritization effect for positive emotions (happy faces), in that they were attended to faster and more accurately compared to angry and neutral faces. This effect is similarly demonstrated by Wild-Wall, Dimigen, and Sommer, (2008), whereby participants carried out facial categorization tasks, findings revealed that positive emotions (happy), facilitated reaction times (faster categorization) compared to negative emotions (disgust).

Negative emotions have also been shown to modulate performance, for example in a study using a visual identification task, participants were shown to have faster reaction times for sad faces compared to neutral (Balsters, Krahmer, Swerts, & Vingerhoets, 2013). Evolutionary accounts of this biased response, suggest that humans have evolved emotions to prepare for an action (Frijda, 2007). Explanations are still widely debated however one explanation is that emotion-prioritization aids threat detection and therefore promotes

survival (Öhman, Lundqvist, & Esteves, 2001). Considering the high importance and relevance to well-being this explains why detection of emotion related stimuli has evolved to become a fast and accurate response (Wenk, 2017).

The automaticity of emotion-processing is supported by neuroimaging studies that suggest that emotion laden stimuli are pre-attentively processed in the amygdala, which is suggested to act as an attentional device that modulates visual responses towards them (Dolan & Vuilleumier, 2003; Pessoa, 2010). Eye-tracking studies show that processing of emotional-stimuli are not only prioritized but also done in an automatic fashion (Hunt, Cooper, Hungr, & Kingstone, 2007). This suggests a relationship between emotions and an instinctive behavioural response towards them.

The literature clearly demonstrates that emotions affect human perception and although there are inconsistencies surrounding the effects of positive and negative emotions, it is likely that happy and sad emotions facilitate performance compared to neutral.

1.4 The relationship between self-prioritization, reward-prioritization and emotion-prioritization effects

Previous literature indicates that self-, reward- and emotion-biases appear to have similar effects on perception, in that stimuli related to self, reward and emotion are all perceptually prioritized, which arguably questions that these effects might somehow be related. This is further elevated by evidence that these effects have similarities in neural processing, for example Enzi, de Greck, Prösch, Tempelmann, and Northoff, (2009), found a neural overlap between self and reward processing, brain imaging revealed that both reward and personal relevance activated subcortical and cortical regions.

This falls in-line with Northoff and Hayes, (2011), Parallel Processing Model which suggests that the processing of self and reward are inextricably linked, in that there are

differential aspects between reward-related and self-specific systems but they are processed in parallel along a self-reward continuum. Support for this model comes from Yankouskaya et al., (2018), adopting Sui et al's, (2012) associative matching procedure, both common and distinct effects were found for the perceptual processes for self-relevance and monetary rewards.

Using the same associative matching procedure Stolte, Humphreys, Yankouskaya, and Sui, (2017), explored the perceptual bias of self and emotion and found a prioritization effect for both self and positive emotion (happy faces) in that they facilitated response time. However a relationship was not found between the two effects, indicating dissociable underlying processes between self and emotion, in that emotion is modulated by self at lower-level processing and separate at higher.

This is supported by neurological evidence for example, Northoff et al's, (2009), fMRI investigations indicate that cognitive mechanisms for self and emotion were distinct in higher cortical regions, including the dorsolateral prefrontal cortex, however they were modulated in the same direction in lower subcortical regions including the amygdala and hypothalamus. Neuroimaging studies have also found self-referential processing to co-operate with the emotional limbic system in a modulatory fashion and indicate both segregation and overlapping between cognitive processes for self-relatedness and emotional appraisal (Hu et al., 2016; Northoff et al., 2006; Northoff et al., 2009; Phan et al., 2004).

Whilst there is little evidence of a relationship between the perceptual effects of reward and emotion, research indicates neural overlaps within the amygdala for both reward and emotion (Pessoa, 2010). Neuroimaging has shown overlapping in neural substrates for the cognitive processing of monetary rewards and smiling faces (Lin, Adolphs, & Rangel, 2012). By following a top-down approach, it could also be considered that emotional stimuli elicit the same response as reward because they enable behavioural preparation so are

considered to have high value towards survival (Brosch et al., 2010; Brosch, Scherer, Grandjean, & Sander, 2013). Amongst the literature at present there is not currently a clear explanation for the similarities between the three biases.

We recently employed a novel approach in a pilot study by expanding upon Sui et al's (2012), associative matching paradigm, by using three variants of the task to test all three biases (self- reward- and emotion-prioritization effects) and examine the relationship between them. We found a prioritization effect (faster response-times and higher accuracy) for self-relevance, positive emotion and high reward. Further correlation analyses revealed a positive relationship between self-relevance and positive emotion. However no significant relationship was found between these and reward-biases. Our findings therefore suggest that there is a differential relationship between self, reward and emotion, and imply that the processes for self-relevance and positive emotion may employ common cognitive and neurobiological mechanisms. Whilst results indicate the effects of reward mimics self- and emotion-biases, findings suggest that distinct mechanisms govern the processing of high versus low values.

Findings from our pilot study question if self-, reward- and emotion-biases are processed in an integrated or hierarchical fashion and highlights that the relationship needs to be further explored. This could be achieved by measuring the brain responses that are a direct result of these effects in order to gain a clear picture of the underlying cognitive processes between them. Collection of electrophysiological data could provide a deeper insight into the cognitive processes involved in self- reward- and emotion biases and through a comparable approach enable a more detailed understanding of the functional relationship between them.

Literature surrounding the time-courses of self and emotion suggests that the processing of self-reference emerges earlier than emotion and that it combines with emotion

at a later stage (Cai, Wu, Shi, Gu, & Sedikides, 2016; Fields & Kuperberg, 2012), for example Zhou et al., (2017), employed an implicit self-referential emotion task to investigate the time-courses of self and emotion. Early automatic processing was observed for self-other discrimination in components N1 (80-110ms) and P1 (170-220ms) in the anterior brain and the processing of emotional valence occurred in the later component of N2 (220-250ms). The interaction between self-reference and emotional valence was found to occur during the late positive potential (LPP; 400-500ms). Findings indicate an early emergence of self-reference and suggests that the self plays a modulatory role on emotion processing.

However it should be noted that the processing of emotionally valenced stimuli has been found to occur as early as that of self-referential processing, in N100, P100, and N170 (a component that reflects early automatic processing to visual stimuli) (Ritter, Simson, & Vaughan, 1983) , for example Kissler, Herbert, Winkler, and Junghofer, (2009), investigated pre-lexical processing of emotional versus neutral words and found that emotional-words were subject to early discrimination in the early P1-N1 time window (100-104ms),in addition Herbert, Herbert, Ethofer, and Pauli, (2011), used an event-related potential (ERP) technique to investigate the interaction between self-other discrimination and emotionality. Findings revealed early processing in N1 for emotional stimuli but conversely self-relatedness and emotion did not interact at the N170 processing stage and was found to interact at the late positivity stage (500-800ms). This therefore suggests that, for emotional stimuli self–other discrimination first occurs at higher-order, cortical processing stages.

Whilst research for the relationship of the temporal properties between self- and reward-biases is sparse, reports have shown larger visual N1(150ms) and P300 amplitudes for high-reward relative to low-reward (van den Berg, Krebs, Lorist, & Woldorff, 2014). Complimentary to this, electrophysiological responses were observed by Jiang, (2018),while participants completed two variants of Sui et al's., (2012), associative matching task,

designed to test self and reward bias effects. Results indicated an increase in amplitude for the N1 component for reward-bias but a decrease in N1 for self-bias. Findings suggest a lack in attentional resources required for self- compared to reward-stimuli and pose differential processing between self- and reward-bias. Arguably this does not necessarily suggest that self and reward bias are different things but in fact some self-relevant information is considered more important such as a big reward than other self related information like one's own keys.

Moreover an ERP study by Zhu, Gu, Wu, & Luo, (2015), examined the feedback-related negativity (FRN) component between self and reward using a gambling task. Results indicated self-reflection significantly reduced amplitude of FRN in the reward condition and suggests that self-processing can have a direct influence on reward processing .This is further supported by neurological correlations of self-referential processing Wei et al., (2013), and evidence that suggests that the processing of self reference enhances the binding of information (Sui & Humphreys, 2015). Therefore, self- and reward-prioritization effects might be related because they share brain regions, or it could be that they occur separately but are processed in parallel.

It could therefore be suggested that the relationship between self, reward and emotion is one of both segregation and collaboration in that these biases have distinct mechanisms that recruit each other in a functional partnership. Whilst there is evidence that highlights an intrinsic relationship between reward, self and emotion, inconsistencies in temporal dynamics (Zhou et al., 2017), variances in neural overlap (Björn et al., 2009) variances in reward type (Izuma, Saito, & Sadato, 2008) and linear discrepancies (Yankouskaya et al., 2018), point that this relationship is not completely understood and supports a need for further research.

Arguably previous literature has been unsuccessful in clearly demonstrating the relationship between these biases because they have used different methodological approaches that have measured these effects across different scales, which may account for

the inconsistencies in historic findings. Our recent approach challenges these previous methodological differences by using a design that allows for strong control of the main variables and examines all three biases along a consistent scale. The current research will therefore provide valuable data towards developing a clearer understanding of the relationship between these three biases.

1.5 Aim and hypotheses of the present research

The current research aims to overcome previous attempts, and expands upon our recent pilot study, making a first step towards clarifying the effects of self-, reward-, and emotional-biases on perception and the relationship between them. To explore these findings further we aim to replicate the previous methodological approach from our pilot study and utilise the same three variants of an associative-matching-task from Sui et al., (2012), whilst also recording the electrophysiological responses to the stimuli. Replication of this method will also allow us to amend any previous limitations in the pilot study, i.e. possible carry over effects between tasks and shape preference between individuals (Dellinger, 2007).

We will therefore examine the temporal-properties of the processing of self-relevance, emotional valence and reward perception. The timing of these responses will provide a measure of the brains communication and could reveal critical aspects of perceptual processing, attentional selection and cognitive appraisal surrounding the effects (Luck, 2014). By taking this approach we aim to see if the effects of self- reward and emotion go beyond behavioural responses and question if there are detectable differences/similarities within the neural networks for the processing of self-, reward- and emotion-biases.

We expect to find self-,reward- and emotion-prioritization effects evident through faster response times and better accuracy performance in shape-label association with self compared to stranger labels, high-reward (£8) compared to low-reward (£2) and positive-

emotion (happy) compared to neutral labels. This is inconsideration to previous reports that self-relevance high-reward and positive-emotion modulate perception and facilitate behaviour (Stolte, Humphreys, Yankouskaya, & Sui, 2017; Sui et al., 2012).

Considering previous reports of early temporal aspects for self- reward- and emotion-processing we expect that the time courses for stimuli associated with self-relevance, high-reward and positive-emotion will reflect early visual processing and automatic attentional capture, evident in enhanced amplitudes of P1,N1,P2 and N2 components, for processing of shape-label pairings with self compared to stranger, high reward (£8) compared to low (£2) and happy compared to neutral labels.

Based on the aforementioned reports, the possibility that the temporal characteristics of brain activity for self-,reward- and emotion-prioritization effects share similarities is considered and the null hypothesis (H_0) is that there will be no relationship between the time-courses for self-reward- and emotion-biases. If this will be the case, this would indicate that different neural mechanisms are underlying the facilitation effects for, self, reward and emotion. Alternatively (H_1) there will be a significant correlation found between them.

2. Method

2.1. Participants

Nineteen adults from Bournemouth University (eleven females) between 18 and 38 years old (M=22.74, SD 6.23), volunteered in the present study. One participant was left-handed, one was ambidextrous, all others were right-handed. All participants reported no neurological or mood disorder conditions and had normal or corrected-to-normal vision.

2.2 Task and Stimuli

The employed tasks were three variants of an associative matching task taken from Sui et al., (2012). Each task was designed to test one of the three prioritization effects (Self/Emotion/Reward) and was run on a PC, using E-Prime software (Version 2.0.10.356). The task, used six geometric shapes (triangle, circle, hexagon, pentagon, square and diamond)(each 0.8˚ x 0.8˚) to which the following labels were randomly assigned (each 3.1˚/3.6 x 1.6˚); Self/ Stranger (Personal task), £8/£2(Reward task),Happy/Neutral(Emotion task). Participants indicated subsequent matched/non-matched shape-label parings via button press (letters M/N) on a standard QWERTY keyboard. All stimuli were displayed on a white background above a black centred fixation cross (0.8˚x 0.8˚), on a Formac ProNitron 21/750 20” monitor. Two sets of 120 simple arithmetic equations on A4 paper were used as a filler task, in line with previous literature (Si, Xu, Feng, Xu, & Zhou, 2014),we designed this to provide a break between tasks and to alleviate any carryover effects (see appendix B1 and B2 for full list of arithmetic equations).

2.3 Procedure

2.3.1 Behavioural Procedure

The experiment took place in a quiet dim lit laboratory at Bournemouth University and began by providing participants with a detailed information sheet, outlining the rationale and subsequent testing procedure, they were advised that accuracy and response times of their performance in paired label-shape associations will be measured, during which brain activities will be recorded with an electroencephalography (EEG) system. Followed by an agreement form whereby participants were advised, they can withdraw at any point and that data will remain anonymous, to which signed consent was provided.

The experimental procedure began by presenting participants with on screen demographic questions including their age, sex and handiness. A random design was used to allocate participants to order of the tasks (for example personal-reward-emotion), depending on which test participants did first, they were then presented with instructions outlining the stimuli-specific labels and that they were required to indicate matching associations with the subsequent presented shapes.

The same procedure was used for each task, but stimuli was specific towards the perceptual bias aimed at testing, for example for the personal task, participants were instructed with the parings; “you are the square and the stranger is the triangle”,for the reward task; “the pentagon is worth £8 and the square is worth £2” and for the emotion task; “the diamond is happy and the octagon is neutral”. Across the trials, shape-label matches were randomized for each participant.

Participants were instructed to press the space bar to start the trial phase, which consisted of 4 practice trials prior to the experimental trials. The trials began with the on-screen presentation of one of the six shapes (triangle, circle, hexagon, pentagon, square and diamond) above a centred fixation cross, with one of the associated labels (self/stranger,

£8/£2 or happy/neutral) below. Participants were required to indicate if the presented shape and label was a match for the primarily given associations. Participants indicated paring judgements via keyboard press of letters M/N, for match or no match (letters were counterbalanced across trials).

For the reward task participants were advised that they could earn up to £5.00 cash bonus based on their accuracy performance per trial block, 0.2% of the face value (i.e. £8/£2) was awarded for correct responses for shape-label pairings (i.e. 100% accuracy in all 5 blocks equates to £5.00). Accuracy was measured through the number of correctly matched trials of each label and response time was measured in milliseconds for each correctly matched trial. In between each task participants were presented with 120 arithmetic equations and were instructed to complete to their best ability as many as they could in three minutes, timings for which were controlled by a stopwatch. Once the time limit had been reached participants were instructed to stop the task.

The timing parameters for the experiment were as follows: the duration of the stimulus presentation was 100 ms, the time for response -1500 ms and the intertribal interval was jittered from 100 ms to 500 ms. There were 5 x 96 trial blocks (120 per condition) for each task (i.e. personal-/reward-/emotion-task), feedback of overall accuracy score was provided on screen after each block. At the end of each block, the screen displayed ‘wait for researcher’ at which stage the researcher would ask the participant if they are happy to continue to the next block. When the participants completed all the blocks, the final screen displayed ‘well done!’ which prompted them that the experiment was over.

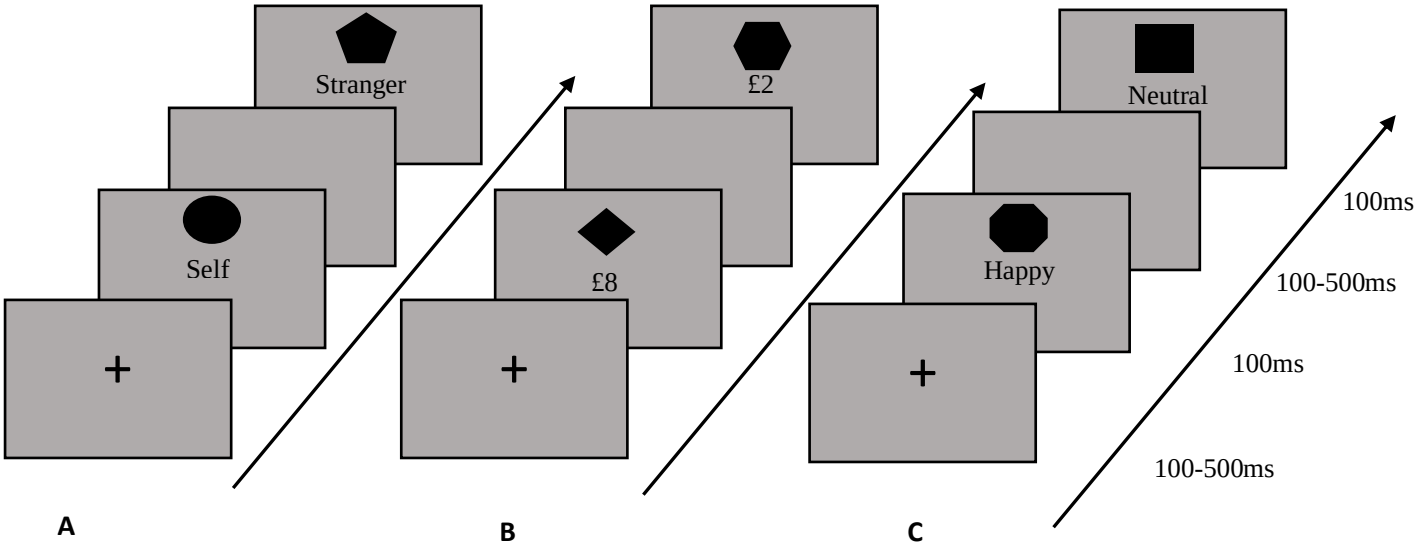

***Figure1*.** An illustrative example of the experimental procedure for the Personal (A), Reward- (B) and Emotion- (C) shape-label matching tasks.

2.3.2 EEG Procedure

EEG were recorded using a 64-channel BioSemi ActiveTwo System whereby 64 electrodes were positioned according to international 10-20 system, Common mode sense (CMS) and driven right leg (DRL) electrodes served as ground. The voltage offset was kept below 40 microvolts. Electrodes were also placed on the left and right mastoids, at left and right temples (horizontal electrooculogram (EOG)) and below the left eye (Vertical EOG) to monitor eyeblinks and vertical/horizontal eye movements.

2.4 Design and analysis

Normality assumptions were investigated using The Shapiro-Wilk test ($p < .05$), histograms, Q-Q plots and box plots were visually inspected, and skewness and kurtosis figures were assessed. The Shapiro-Wilk test was chosen above that of Kolmogorov-Smirnov

because it was considered more appropriate for the small sample size (Guo, 2012; Zimmerman, 2003).

2.4.1. Behavioural analysis

One of the participants data had to be excluded from behavioural analysis because they achieved below 60 percent accuracy. We deleted response times <100 ms, fast guesses were 2.6% out of all trials, we removed all trials with incorrect responses. The mean number of correct responses were calculated for each participant for each label in each task. A 3 (Task: Personal, Reward, Emotion) x2 (Trial Type: Match, Mismatch) repeated-measures analysis of variance (rm-ANOVA) was conducted on accuracy and response time (RT) data following which a 3 (Task: Personal, Reward, Emotion) x2 (Saliency; High/Low) rm-ANOVA was conducted on accuracy data for matched trials and RT data for match and mismatched trials. The null hypothesis was tested against RT and accuracy data using a Bayesian rm-ANOVA.

The advantages in performance (perceptual bias) were calculated by comparing RT and accuracy between labels and represent the measure of advantages in speed of response for each label in each task. This was done using the following calculations personal-task; (stranger) – (self), reward-task; (£8) – (£2), emotion-task; (happy) - (neutral), for accuracy and RT data. Correlation analyses using Pearson product-moment correlation coefficient (PPMCC) *(two-tailed)* and Bayesian Pearson correlation were performed on the self-reward and emotion-bias for RT and accuracy data.

2.4.2. EEG analysis

All data were processed using MATLAB (MathWorks, Inc., Natick, MA, USA), eyeblinks and noisy channels were removed, data were segmented in to 20ms windows

following the grand-average localiser. Analysis consisted of two stages the first was based on raw wave forms and the second was based on effects on component amplitude.

Measures from multiple channels were averaged over before analysis, we used a 100-ms pre stimulus baseline for the averaging, in cases where the activities were lateralised in distribution an additional factor of hemisphere was applied. The P1 component was observed over the lateral parieto-occipital regions and was measured as the mean voltage between 97-115ms. The channels PO8 O2 PO4 (Right Hemisphere) and PO7 O1 PO3 (Left Hemisphere) were averaged together for analysis. The P1 effect was maximal at the occipito-parietal regions and was measured as the mean voltage between 74-94ms. The channels PO4, PO3 and POz were averaged together for analysis.

The anterior N1 component was observed over the bilateral fronto-central regions and was measured as the mean voltage between 105-125ms, the channels FCz, Fz, F3 and F4 were averaged together for analysis. The posterior N1 component was observed over the lateral parietal and occipito- parietal sites and was measured as the mean voltage between 152-172ms. The channels PO7 P7 P9 (Left Hemisphere) and PO8 P8 P10 (Right Hemisphere) were averaged together for analysis.

The anterior P2 component was observed over the lateral and frontal and fronto-central sites and was measured as the mean voltage between 197-217ms. The channels F3, F5, FC3 (Left Hemisphere) and F6, F4, FC4 (Right Hemisphere) were averaged together for analysis. The posterior P2 component was observed at the posterior midline sites and was measured as the mean voltage between 213-233 ms. The channels Pz and POz were averaged together.The posterior P2 effect was observed at the occipito-parietal and occipital sites and was measured as the mean voltage between 203-223 ms .The channels PO3, POz,PO4 and O1,Oz,O2 were averaged together for analysis.

The posterior N2 component was observed at the lateral parietal and occipito- parietal sites and was measured as the mean voltage between 220-280 ms. The channels PO7 P7 P9 (Left Hemisphere) and PO8 P8 P10 (Right Hemisphere) were averaged together for analysis. The anterior N2 (275ms) was very weak so was not analysed.

The P3 component was observed at the parieto-central, parietal and occipito-parietal sites and was measured as the mean voltage between 326-356 ms. The channels Pz, P1, P2, POz and CPz were averaged together for analysis.

Mean component amplitudes and effects were analysed with a 3 (Task: Personal, Reward, Emotion) x2 (Saliency: High/Low) (x2 (Hemisphere: Right/Left) for components that were lateralised) rm-ANOVA. The null hypothesis was tested against ERP amplitude and effect data using a Bayesian rm-ANOVA.

Bias between conditions for each component was calculated on amplitude and effect data using the following calculations for each task; personal-task; (stranger) – (self), reward-task; (£8) – (£2), emotion-task; (happy) - (neutral) (hemisphere was collapsed for bias calculations by averaging the two amplitudes together). Self- reward- and emotion-bias for each component was subject to correlation analysis using PPMCC *(two-tailed)* and Bayesian Pearson correlation.

3. Results

3.1. Behavioural data

3.1.1. Accuracy

To test the effects of Trial Type on accuracy performance, a 3 (Task: Personal, Reward, Emotion) x2 (Trial Type: Match, Mismatch) repeated-measures analysis of variance (rm-ANOVA) was conducted on accuracy data. Mauchly's test of sphericity showed that the assumption of equal variance between the trials was violated, [$\chi^2(2) = 8.48$, $p = .02$] therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .71$). All effects on accuracy performance were not significant ; Task [F (1.42,24.1) =1.28, $p = .29$, $\eta_p^2 = 0.07$], Trial Type [F (1,17) = .92, p =.35, $\eta_p^2 = 0.05$] and Task and Trial Type, [F (1.95,33.19) = 2.27, p =.12, $\eta_p^2 = 0.12$].Thus, results indicate that there is no significant difference between Matched and Mismatched trials for the accuracy performance across all the Tasks.

Furthermore, a Bayesian rm-ANOVA provides strong evidence against the alternative hypothesis (i.e., that there is a significant main effect of Task, BF= $BF_{10} = 0.94$, Trial Type, $BF_{10} = 0.22$; and a significant interaction between Task and Trial Type, $BF_{10} = 0.04$) (see evidence from comparisons of posterior distributions in Appendix, Figures 1a, 2a and 3a). Therefore, further analysis will only focus on Matched trials thereafter.

The normality tests for accuracy data for Matched Trials in Task were all significantly non normal, however skewness and kurtosis figures were all relatively small (Byrne, 2010),(Hair, 2010).Considering that an Analysis of Variance (ANOVA) is a method that is sensitive to moderate deviation simulation data (Hair, 2010) and taking the normality results in to account, this would suggest that a parametric test would be an appropriate way to handle

the data. Therefore, further analysis will be conducted using a rm-ANOVA. (Descriptive statistics for accuracy data for Matched trials are displayed in Table.1).

Table 1

Mean and Standard deviation (SD) for accuracy performance (percent correct responses) in Matched trials for all Task conditions.

	Self	Stranger	£8	£2	Happy	Neutral
Mean	94.86	91.06	93.94	93.80	93.84	87.92
Std. Deviation	5.69	7.61	7.53	7.24	9.80	11.15

To test the effect of Saliency on Accuracy performance, a 3 (Task: Personal, Reward, Emotion) x2 (Saliency; High/Low) rm-ANOVA was conducted on accuracy performance for matched trials. There was a significant main effect of Saliency [F (1,17) = 5.11, p =.03, η_p^2 = 0.24], accuracy performance was higher for high saliency in the personal task (Self) (M= 94.86, SD=5.69) compared to low saliency (Stranger) (M = 91.07, SD = 7.61), and higher for high saliency in the emotion task (Happy) (M= 93.8, SD=9.8) compared to low saliency (Neutral) (M = 87.92, SD = 11.15). However all other effects were not significant; Task [F (2,34) =1.43, p = .25, η_p^2 = 0.08]and Task and Saliency [F (2,34) = 1.84, p =.17, η_p^2 = 0.09].

Furthermore a Bayesian rm-ANOVA performed on accuracy data for Match trials support the results that there was no effect of Task (BF_{10} = 0.31) and no interaction between Task and Saliency (BF_{10} = 0.33) (see evidence from comparisons of posterior distributions in Appendix 1, Figures 4a,5a). Bayes Factor support the alternative hypothesis for the effect of Saliency on accuracy performance (i.e., that high saliency stimuli yield higher accuracy

compared to low salience stimuli) (see evidence from comparisons of posterior distributions in Appendix 1, Figure 6a). However, the evidence is classified as anecdotal (Jeffreys, 1961) BF_{10} = 2.33.

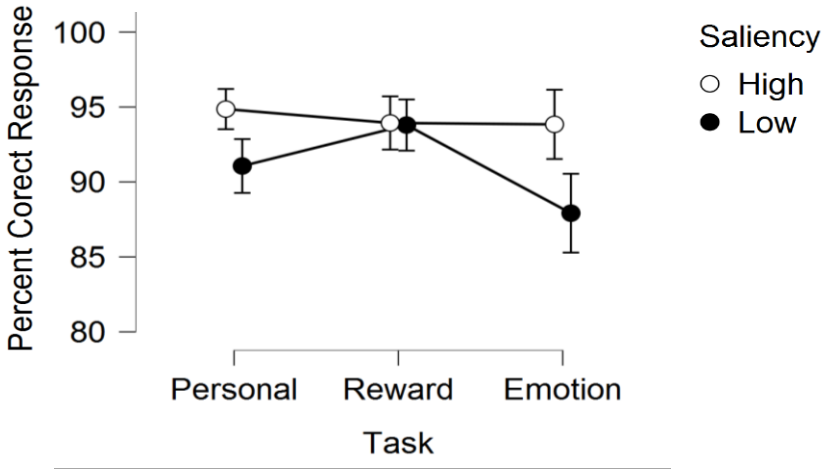

Figure 2. Percent correct response for Saliency (high/low) in Task (personal, reward and emotion) (SD are displayed in the error bars).

This figure demonstrates that accuracy performance was higher for high saliency stimuli in the personal- and emotion-task compared to low and there were no differences between high and low saliency stimuli in the reward-task.

The relationship between Self- Reward- and Emotion-bias in accuracy performance (Matched trials) was analysed using a Pearson product-moment correlation coefficient (PPMCC) *(two-tailed)* (correlation results are displayed in Table 2).

Table 2

Correlation results between Self- Reward and Emotion-bias in accuracy performance. Significant differences between pairings are marked with '*'.

	r	*P*	BF_{10}
Self- and Reward-bias	-.21	.40	0.40
Self- and Emotion-bias	.48	.04*	1.98
Reward- and Emotion-bias	-.07	.79	0.30

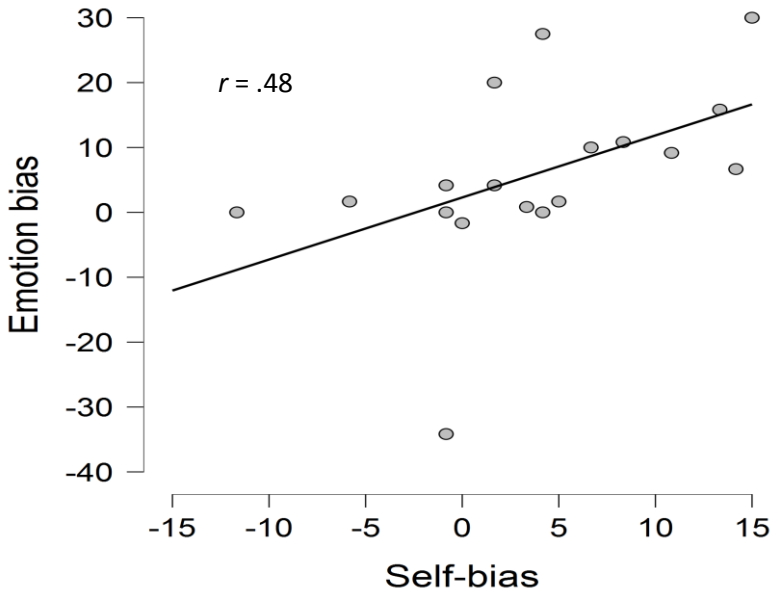

Figure 3. The perceptual bias for accuracy performance in Self-task on bias in Emotion-task (Matched trials). This figure demonstrates a moderate positive relationship between Self- and Emotion-prioritization effects.

3.1.2. Response-Time

Response-time (RT) data for all conditions in Task for Trial Type (Match/Mismatch) were all significantly normal and therefore satisfy normality assumptions that the data is normally distributed. (Descriptive statistics for RT data are displayed in Table.3).

Table 3

Mean and SD for RT (ms) in Matched and Mismatched trials for personal- reward- and emotion-tasks.

	Personal Match	Personal Mismatch	Reward Match	Reward Mismatch	Emotion Match	Emotion Mismatch
Mean	698	760	705	756	713	770
Std. Deviation	103	109	90	89	111	121

To test the effects of Trial Type on RT, a 3 (Task: Personal, Reward, Emotion) x2 (Trial Type: Match, Mismatch) rm-ANOVA was conducted on RT data. There was a significant main effect of Trial Type [F (1,17) = 212.88, p <.001, η_p^2 = 0.26] however no other significant effects were found ; Task [F (2.34) =.25, p = .78, η_p^2 = 0.01],Task and Trial Type [F (2,34) = 1.25, p =.30, η_p^2 = 0.002].

Furthermore a Bayesian rm-ANOVA performed on RT data support the results that there was no effect of Task (BF_{10} = 0.12) and no interaction between Task and Trial Type (BF_{10} = 8629.41) (see evidence from comparisons of posterior distributions in Appendix 1, Figures 7a,8a). Bayes Factor support the alternative hypothesis for the effect of Trial Type on RT (BF_{10} = 60221.04) (i.e., that Match yield lower RT compared to Mismatched stimuli) (see evidence from comparisons of posterior distributions in Appendix 1, Figure,9a).Therefore, further analysis will focus on both Match and Mismatched trials thereafter.

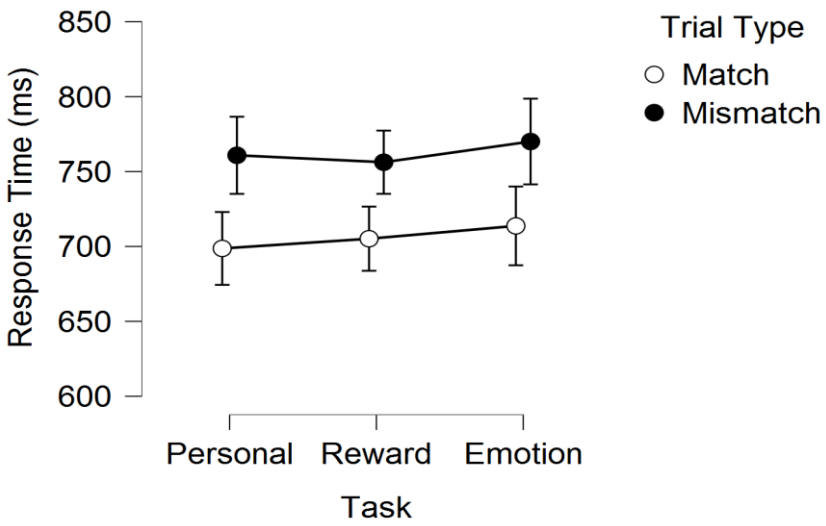

Figure 4. RT for Trial Type (Match/Mismatched) in Task (personal, reward and emotion) (SD are displayed in the error bars).

This figure demonstrates that RT was lower for Matched Trials in Task compared to Mismatched Trials in Task.

3.1.2.1. Mismatched Trials

To test the effects of Saliency on RT for the mismatched trials, a 3 (Task: Personal, Reward, Emotion) x2 (Saliency; High/Low) rm-ANOVA was conducted on RT data. There was a significant main effect of Saliency [F (1,17) = 5.42, p =.03, η_p^2 = 0.24], RT was lower for high saliency in the personal task (Self) (M= 749.99, SD=108.39) compared to low saliency(Stranger) (M = 771.69, SD = 112.37) , no other significant effects were found ; Task [F (2,34) =0.22, p = .80, η_p^2 = 0.01] and Task and Saliency [F (2,34) = 2.23, p =.12, η_p^2 = 0.12]. Furthermore a Bayesian rm-ANOVA performed on RT data for mismatched trials

support the results that there was no effect of Task (BF_{10} = 0.13) and no interaction between Task and Saliency (BF_{10} =0.05) (see evidence from comparisons of posterior distributions in Appendix 1, Figures 10a,11a). However, Bayes Factor failed to support the alternative hypothesis for the effect of Saliency (BF_{10} =0.37) (i.e., that High Saliency yield lower RT compared to Low saliency stimuli) (see evidence from comparisons of posterior distributions in Appendix 1, Figure,12a)

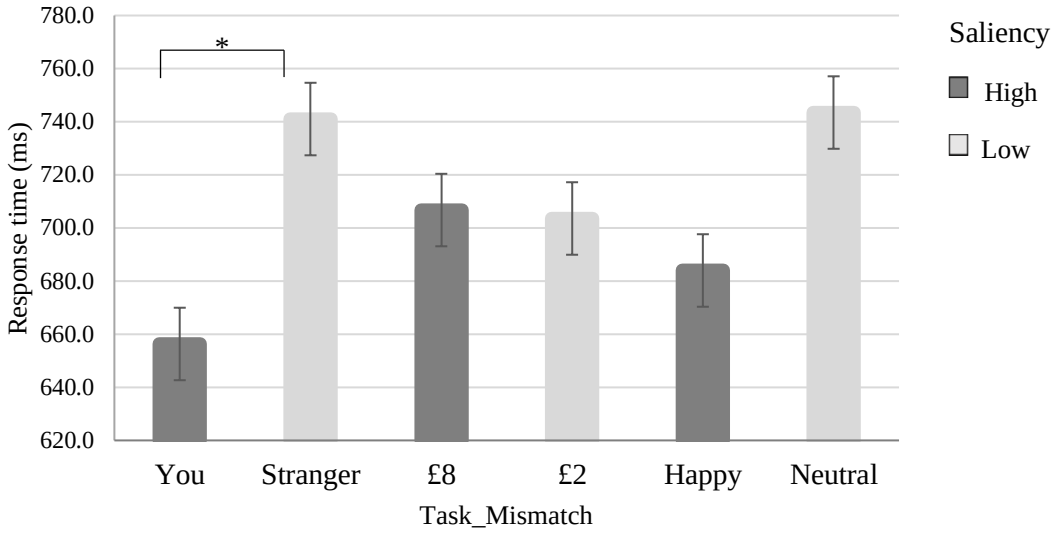

Figure 5. RT for Saliency (High/Low) in Task (personal, reward and emotion; Mismatched Trials) (SD are displayed in the error bars). Significant differences between conditions are marked with '*'.

This figure demonstrates that RT was lower for high saliency stimuli (self) in the personal-task compared to low (stranger),higher for high saliency stimuli (happy) in the emotion-task compared to low (neutral) and there were no differences in RT between high (£8)and low (£2) saliency stimuli in the reward task.

The relationship between Self- Reward- and Emotion-bias for RT (Mismatched trials) was analysed using a PPMCC (*two tailed*). (Correlation results are displayed in Table.4).

Table 4

Correlation results between Self- Reward and Emotion-bias for RT (Mismatched trials).

	R	*p*	BF_{10}
Self- and Reward-bias	-.07	.78	0.30
Self- and Emotion-bias	.36	.14	0.80
Reward- and Emotion-bias	.10	.69	0.31

3.1.2.2. Matched Trials

To test the effects of Saliency on RT for the matched trials, a 3 (Task: Personal, Reward, Emotion) x2 (Saliency; High/Low) rm-ANOVA was conducted on RT data. Mauchly's test of sphericity showed that the assumption of equal variance between the trials was violated, [$\chi^2(2) = 8.37$, $p = .02$]. Therefore, degrees of freedom were corrected using the Huynh-Feldt estimates of sphericity ($\varepsilon = .91$). There was a significant main effect of Saliency [F (1,17) = 11.75, p =.003, $\eta_p^2 = 0.41$], mean RT was lower for High saliency (Self) (M= 656.32, SD=104.49) compared to Low saliency (Stranger) in the personal task (M = 741.01, SD = 107.37), and lower for high saliency (Happy) (M= 683.99, SD=127.14) compared to low saliency (Neutral) in the emotion task (M = 741.43, SD = 126.72).

There was a significant interaction between Task and Saliency [F (1.82,30.86) = 7.30, p =.003, $\eta_p^2 = 0.30$], however there was no significant main effect of Task [F (1.82,30.86) =0.36, p = .68, $\eta_p^2 = 0.02$]. Furthermore a Bayesian rm-ANOVA performed on RT data of Matched trials support the results that there was no effect of Task ($BF_{10} = 0.12$) and an interaction between Saliency on Task ($BF_{10} = 4.04$) (see evidence from comparisons of posterior distributions in Appendix 1, Figures 13a,14a). Bayes Factor supports the alternative hypothesis for the effect of Saliency ($BF_{10} = 33.93$) (i.e., that High Saliency yield

lower RT compared to Low Saliency stimuli) (see evidence from comparisons of posterior distributions in Appendix 1, Figure 15a)

To test a significant interaction between Task and Saliency a Post-Hoc test was carried out using the Bonferroni correction (α altered = .05/15) =.003 (rounded) and indicated that RT in personal-task for High Saliency (Self) compared to Low Saliency (Stranger) significantly differed (MDiff= -84.7, SE=19.6, *t* (17) = 4.32, *p*= .001). There were no other significant pairings between Task and Saliency.

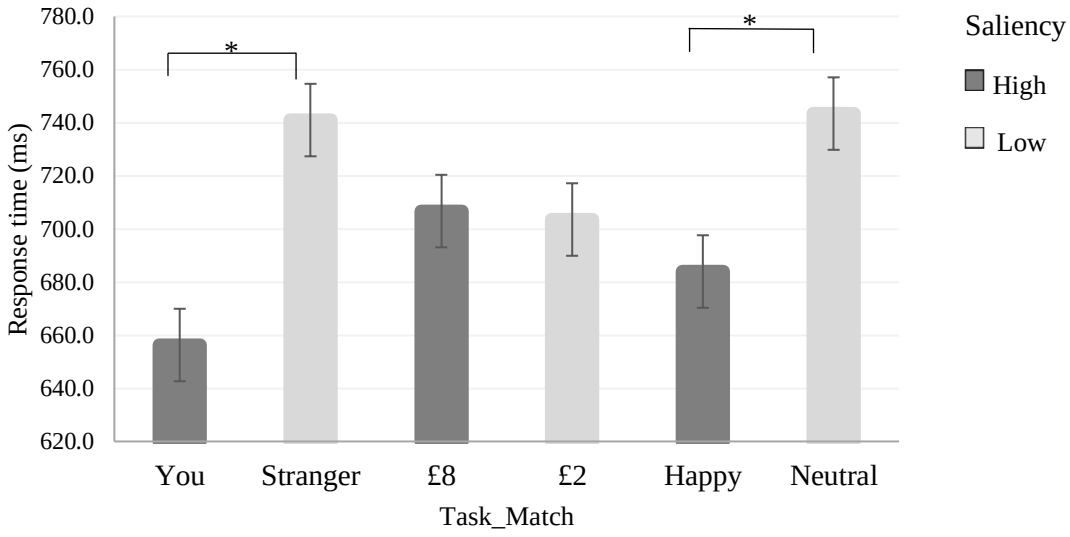

Figure 6. RT for Saliency (High/Low) in Task (personal, reward and emotion) (Match trials) (SD are displayed in the error bars). Significant differences between conditions are marked with '*'.

This figure demonstrates that RT was lower for high saliency stimuli (self) in the personal-task compared to low (stranger),higher for high saliency stimuli (happy) in the emotion-task compared to low (neutral) and there were no differences in RT between high (£8)and low (£2) saliency stimuli in the reward task.

The relationship between Self- Reward- and Emotion- prioritization effects for RT (Matched trials) was analysed using a PPMCC (*two tailed*). (Correlation results are displayed in Table.5).

Table 5

Correlation results between Self- Reward and Emotion-bias for RT (Matched trials). Significant differences between pairings are marked with '*'.

	r	*p*	BF_{10}
Self- and Reward-bias	-.16	.54	0.35
Self- and Emotion-bias	-.01	.69	0.31
Reward- and Emotion-bias	.72	< .001*	49.88

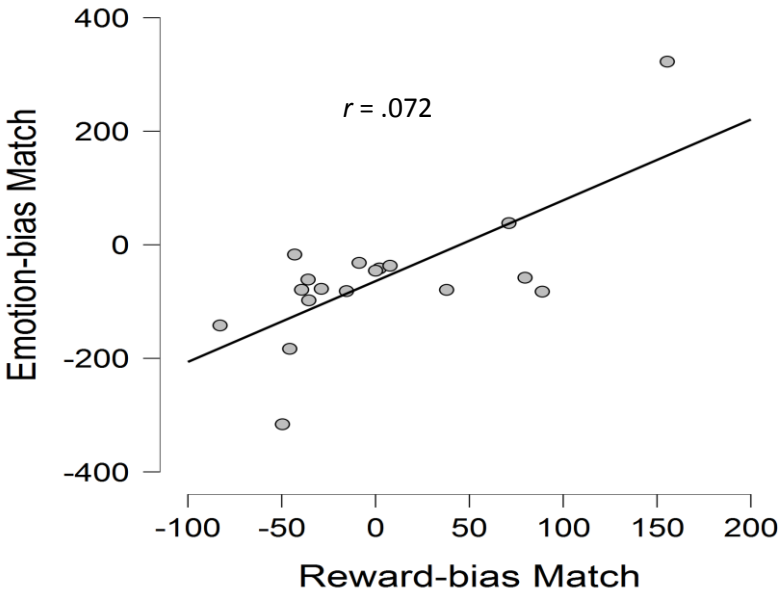

Figure 7. The perceptual bias for RT performance for Reward-task on bias in Emotion-task (Matched trials). This figure demonstrates a strong positive relationship between Reward- and Emotion-prioritization effects.

3.1.3. Electrophysiological data

3.1.3.1. P1 amplitude

The P1 amplitude data in all Tasks were all significantly normal and therefore satisfy normality assumptions that the data is normally distributed. (Descriptive statistics for P1 mean amplitude data are displayed in Table.6).

Table 6

The Mean (SD in brackets) for P1 amplitude (μV)in left (LH) and right hemisphere (RH) for all conditions in personal- reward- and emotion tasks.

	LH	RH
Self	2.73(3.23)	3.61(3.94)
Stranger	3.21 (2.97)	3.5(3.56)
£8	3.01(3.03)	4.05(3.39)
£2	2.97(3.54)	4.0(3.9)
Happy	2.31(2.12)	2.54(2.27)

Neutral	2.59(3.2)	3.25(3.86)

P1 amplitudes were analysed with a 3 (Task: Personal, Reward, Emotion) x2 (Saliency: High/Low) x2 (Hemisphere: Right/Left) rm-ANOVA. All effects on P1 amplitude were not significant ;Task [F (2,36) = 1.39, p = .26, η_p^2 = 0.07], Saliency[F (1,17) = 0.49, p =.49, η_p^2 = 0.03] hemisphere [F (1,18) = 2.79, p =.11, η_p^2 = 0.13 Task and Saliency [F (2,36) = 0.26, p =.77, η_p^2 = 0.02] Task and Hemisphere [F (2,36) = 1.4, p =.26, η_p^2 = 0.07] and Saliency and Hemisphere [F (1,36) = 0.02, p =.88, η_p^2 = 0.001]and Task, Saliency and Hemisphere[F (2,36) = 1.22, p =.31, η_p^2 = 0.06].

Furthermore a Bayesian rm-ANOVA performed on P1 amplitude support the results that there was no effect between all factors; Task (BF_{10} = 0.64), Saliency (BF_{10} = 0.18), Hemisphere (BF_{10} = 2.07), Task and Saliency (BF_{10} =0.12) Task and Hemisphere (BF_{10} =1.44) Saliency and Hemisphere (BF_{10} =0.38),Task, Saliency and Hemisphere (BF_{10} =0.26) (see evidence from comparisons of posterior distributions in Appendix 1, Figures 16a,17a,18a,19a,20a,21a,22a).

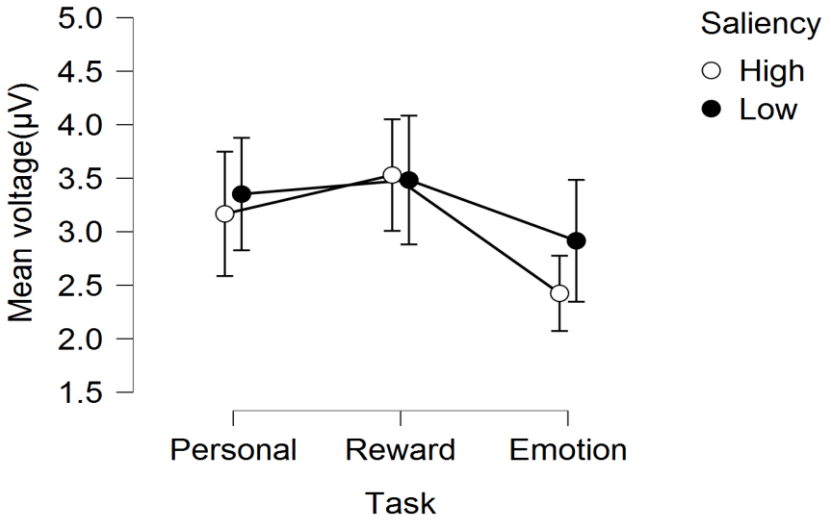

Figure 8. Mean P1 amplitude (µV) for Saliency (High/Low) in Task (personal, reward and emotion) (SD are displayed in the error bars).

The relationship between Self- Reward- and Emotion-bias for P1 amplitude was analysed using a PPMCC (correlation results are displayed in Table 7).

Table 7

Correlation results between Self- Reward and Emotion-bias for P1 amplitude (µV).

	r	*p*	BF_{10}
Self- and Reward-bias	.13	.59	0.33
Self- and Emotion-bias	.06	.78	0.29
Reward- and Emotion-bias	-.27	.25	0.52

3.1.3.2. P1 effect

The data for P1 effect (i.e. the differences in P1 amplitude between each condition for each task (Self vs Stranger, £8 vs £2, Happy vs Neutral) were all significantly normal and therefore satisfy normality assumptions that the data is normally distributed. (Descriptive statistics for P1 effect are displayed in Table.8).

Table 8

Mean and SD for mean amplitude (μV) of the P1 effect for all conditions in personal-reward- and emotion tasks.

	Self	Stranger	£8	£2	Happy	Neutral
Mean	1.45	3.43	0.57	1.19	2.05	2.65
Std. Deviation	2.99	1.90	2.38	2.47	2.09	2.31

P1 effect was analysed with a 3 (Task) x2 (Saliency) rm-ANOVA. There was a significant main effect of Task [F (2,36) = 8.7, p <.001, η_p^2 = 0.33], and a significant main effect of Saliency [F (1,18) = 16.96, p <.001, η_p^2 = 0.49] , Mean P1 effect was greater for low saliency (Stranger) (M = 3.43, SD = 1.89) compared with high saliency (Self) (M= 1.45, SD=4.28) in the personal task and greater for high saliency (Happy) (M = 2.05, SD = 2.09) compared to high saliency in the reward task(£8) (M= 0.57, SD=2.38). However no significant interaction was found between Task and Saliency [F (2,36) = 5.96, p =.11, η_p^2 = 0.12].

Furthermore a Bayesian Repeated measures ANOVA performed on mean amplitude of P1 effect supports the results of a significant effect of Task (BF_{10} = 122.13) and a

significant effect of Saliency (BF_{10} = 13.27). Bayes Factor support the alternative hypothesis for the interaction between Task and Saliency (BF_{10} = 3619.03) (i.e., that there will be a difference in mean amplitude for high Saliency compared with low saliency between the tasks), (see evidence from comparisons of posterior distributions in Appendix 1, Figures 53a,54a,55a,).

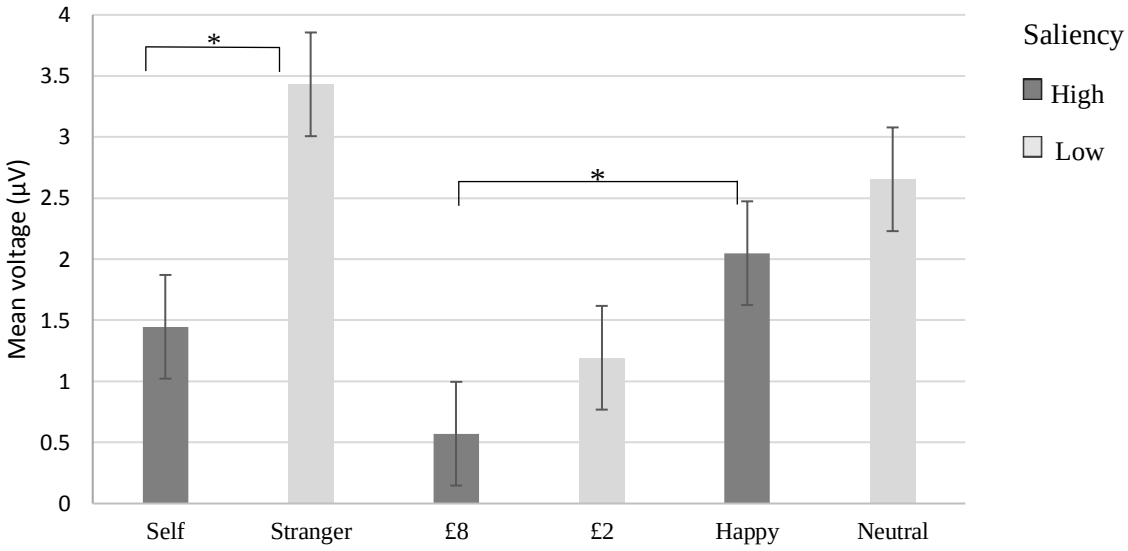

Figure 9. Mean P1 effect for Saliency (High/Low) in Task (personal, reward and emotion) (SD are displayed in the error bars) significant differences are marked with '*'.

This figure demonstrates that P1 effect was greater for Low saliency (Stranger) compared to high saliency (Self) in the personal task and greater for high saliency (Happy) in the emotion task compared with high saliency (£8) in the reward task.

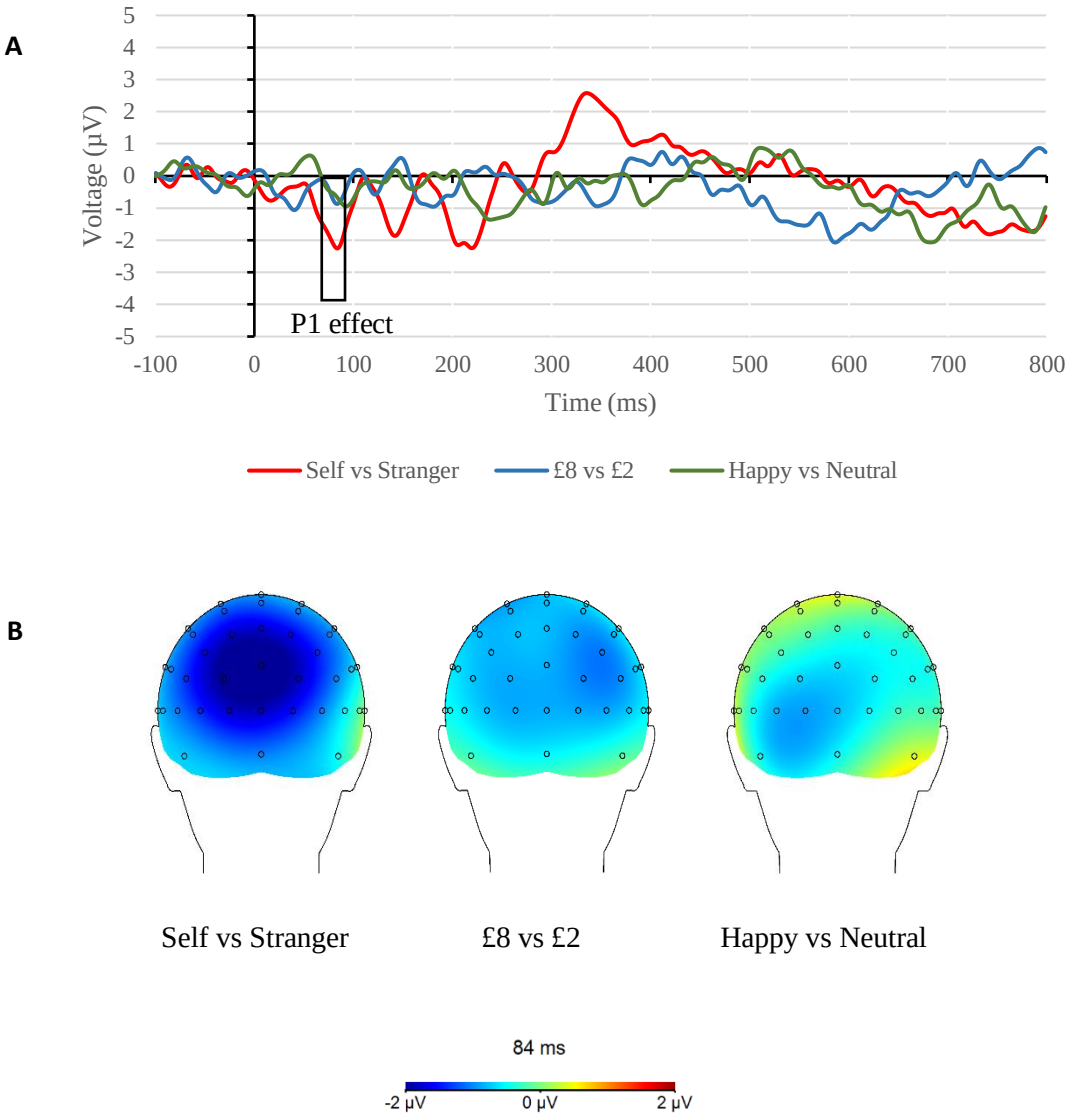

Figure 10. Waveforms (A) and Topographic maps(B) of difference between Personal- Reward- and Emotion-conditions for P1 effect (74-94ms), calculated using the average of channels PO4, PO3 and POz.

The relationship between Self- Reward- and Emotion-bias for P1 effect was analysed using a PPMCC (*two-tailed*) (correlation results are displayed in Table.9.)

Table 9

Correlation results between Self- Reward and Emotion-bias for P1 effect(μV).

	r	*P*	BF_{10}
Self- and Reward-bias	-.36	.13	0.85
Self- and Emotion-bias	.15	.53	0.34
Reward- and Emotion-bias	.32	.18	0.66

3.1.3.3. Anterior N1 amplitude

Data for anterior N1 amplitude in all Tasks were all significantly normal and therefore satisfy normality assumptions that the data is normally distributed. (Descriptive statistics for anterior N1 amplitude are displayed in Table.10)

Table 10

Mean and SD for anterior N1 amplitude (μV) for all conditions in personal- reward- and emotion task.

	Self	Stranger	£8	£2	Happy	Neutral
Mean	-3.10	-2.97	-3.53	-2.31	-2.01	-3.36
Std. Deviation	2.06	3.28	3.16	3.42	3.22	2.85

The anterior N1 amplitude was analysed using a 3 (Task) x 2 (Saliency) rm-ANOVA. There was a significant interaction between Task and Saliency [F (2,36) = 6.26, p =.005, η_p^2 = 0.26],no other significant effects were found; Task [F (2,36) = 0.32, p = .73, η_p^2 = 0.02], Saliency[F (1,17) = 3.11, p = .99, η_p^2 = 1.72].

To test a significant interaction between Task and Saliency a Post-Hoc test was carried out using the Bonferroni correction. (α altered = .05/15) =.003 (rounded). However the Post-Hoc analysis did not indicate any significant pairings.

Furthermore a Bayesian rm-ANOVA performed on anterior N1 amplitude support the results that there was no effect of Task (BF_{10} = 0.11) nor of Saliency (BF_{10} = 0.19) (see evidence from comparisons of posterior distributions in Appendix 1, Figures 23a,24a,). However Bayes Factor failed to support the alternative hypothesis for the interaction between Task and Saliency (i.e. that high saliency yield increased N1 amplitude in Task; self versus stranger, £8 versus £2 and Happy versus Neutral) (BF_{10} = 0.02) (see evidence from comparisons of posterior distributions in Appendix 1, Figure 25a).

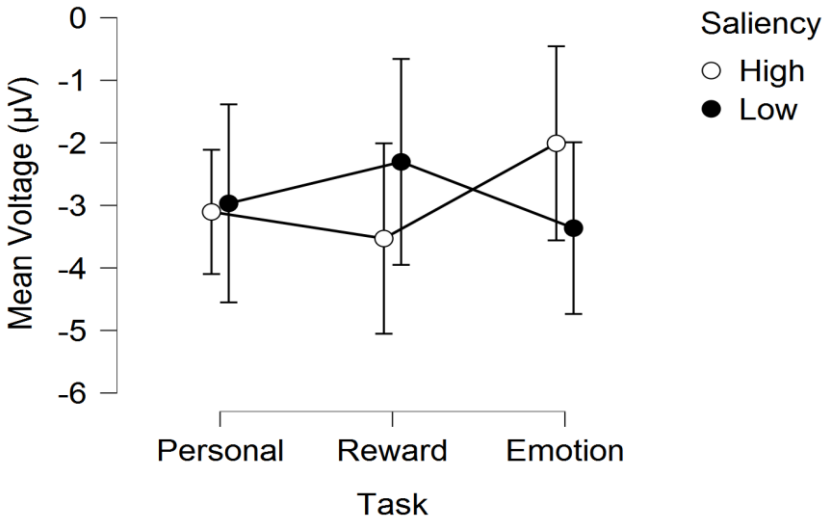

Figure 11. Mean anterior N1 amplitude for Saliency (High/Low) in Task (personal, reward and emotion) (standard deviations are displayed in the error bars).

The relationship between Self- Reward- and Emotion-bias for anterior N1 amplitude was analysed using a PPMCC (*two-tailed*) (correlation results are displayed in Table 11).

Table 11

Correlation results between Self- Reward and Emotion-bias for anterior N1 amplitude(μV).

	r	*P*	BF_{10}
Self- and Reward-bias	.23	.35	0.42
Self- and Emotion-bias	.12	.63	0.32
Reward- and Emotion-bias	.17	.48	0.36

3.1.3.4. Posterior N1 amplitude

Data for posterior N1 amplitude in all Tasks were all significantly normal and therefore satisfy normality assumptions that the data is normally distributed. (Descriptive statistics for posterior N1 are displayed in Table.12).

Table 12

Mean (SD in brackets) for posterior N1 amplitude (μV) for left (LH)and right hemisphere (RH) in all conditions for personal- reward- and emotion tasks.

	LH	RH
Self	-5.03(3.5)	-3.62(3.5)
Stranger	-4.28 (2.68)	-3.64(3.18)
£8	-3.98(2.78)	-5.24(3.11)
£2	-4.33 (2.69)	-5.17(2.69)
Happy	-5.4(2.67)	-5.4(2.67)
Neutral	-4.39(3.34)	-3.55 (3.8)

The posterior N1 amplitude was analysed using a 3 (Task) x2 (Saliency) x2 (Hemisphere) rm-ANOVA. There was a significant interaction between Task and Hemisphere (degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .72$) [F (1.44,25.84) = 10.03, p =.002, η_p^2 = 0.36] all other effects were not significant ;Task [F (2,36) = 1.2, p = .32, η_p^2 = 0.06], Saliency[F (1,18) = 0.68, p =.42, η_p^2 = *0.04*], Hemisphere [F (1,18) = .34, p =.57, η_p^2 = 0.02],Task and Saliency [F (2,36) = 0.62, p =.55, η_p^2 = 0.03],Saliency and Hemisphere[F (1.18) = 0.02, p =.88, η_p^2 = 0.001], Task, Saliency and Hemisphere[F (2,36) = 1.51, p =.23, η_p^2 = 0.08].

Furthermore a Bayesian rm-ANOVA performed on posterior N1 amplitude support the results that there was no effect of; Task (BF_{10} = 0.17), Saliency (BF_{10} = 0.17),Hemisphere (BF_{10} = 0.29), Task, and Saliency (BF_{10} = 0.03),Saliency and Hemisphere (BF_{10} = 0.05) and Task, Saliency and Hemisphere (BF_{10} = 0.01) (see evidence from comparisons of posterior distributions in Appendix 1, Figures 26a,27a,28a,29a,30a,31a). However Bayes Factor failed to support the alternative hypothesis for the interaction between Task and Hemisphere (i.e. that there will be a difference between posterior N1 amplitude in Right Hemisphere for Task compared with Left Hemisphere) (BF_{10} = 0.05) (see evidence from comparisons of posterior distributions in Appendix 1, Figure 32a).

To test a significant interaction between Task and Hemisphere a Post-Hoc test was carried out using the Bonferroni correction (α altered = .05/15) =.003 (rounded). However the Post Hoc analysis indicated that there were no significant pairings.

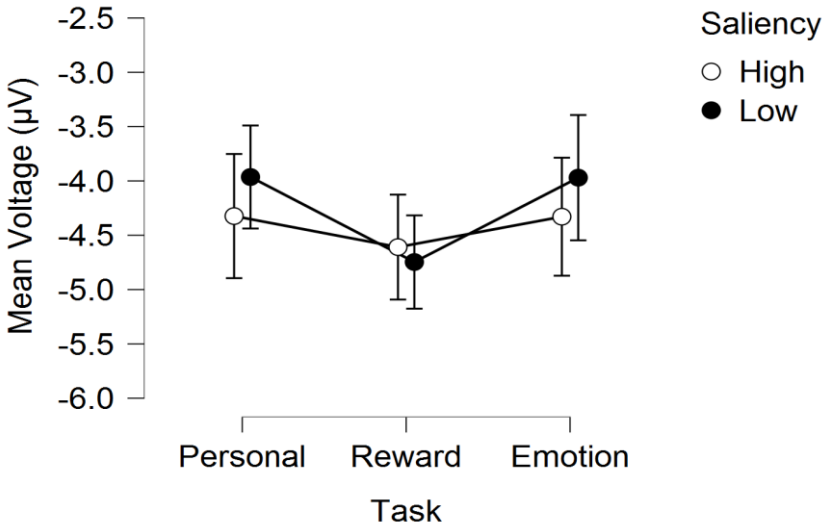

Figure 12. Mean posterior N1 amplitude for Saliency (High/Low) in Task (personal, reward and emotion) (SD are displayed in the error bars).

The relationship between Self- Reward- and Emotion-bias for posterior N1 amplitude was analysed using a PPMCC (*two-tailed*) (correlation results are displayed in Table.13).

Table 13

Correlation results between Self- Reward and Emotion-bias for posterior N1 amplitude (μV).

	r	*p*	BF_{10}
Self- and Reward-bias	-.17	.50	0.35
Self- and Emotion-bias	-.09	.72	0.30
Reward- and Emotion-bias	.09	.72	0.30

3.1.3.5. Anterior P2 amplitude

Data for anterior P2 amplitude in Right hemisphere for high saliency in the personal-task (Self) was significantly non normal and therefore violated normality assumptions. However skewness and kurtosis figures were all relatively small (Byrne, 2010; Hair, 2010). All other data for anterior P2 amplitude were significantly normal. (Descriptive statistics for anterior P2 are displayed in Table.14).

Table 14

Mean (SD in brackets) for the anterior P2 amplitude(μV) for left (LH)and right hemisphere (RH) for all conditions in personal- reward- and emotion tasks.

	LH	RH
Self	3.7(3.78)	-3.66(4.04)
Stranger	2.96(3.58)	2.70 (3.38)
£8	2.5 (3.97)	2.38 (3.32)
£2	2.83 (3.67)	2.64 (3.27)
Happy	2.27 (3.88)	1.99 (3.53)

Neutral	2.38 (4.64)	2.39 (4.21)

P2 amplitude was analysed with a 3 (Task) x2 (Saliency) x2 (Hemisphere) rm-ANOVA. No significant main effect was found across all factors ; Task [F (2,36) = 1.46, p = .25, η_p^2 = 0.08], Saliency[F (1,18) = 0.08, p =.76, η_p^2 = 0.01] Hemisphere [F (1,18) = .17, p =.69, η_p^2 = 0.01], Task and Saliency [F (2,36) = 1.51, p =.23, η_p^2 = 0.08], Task and Hemisphere [F (2,36) = 0.02, p =.99, η_p^2 = 9.34],Saliency and Hemisphere[F (1.18) = 1.47, p =.99, η_p^2 = 8.18],Task, Saliency and Hemisphere[F (2,36) = 0.29, p =.75, η_p^2 = 0.02].

Furthermore a Bayesian Repeated measures ANOVA performed on mean amplitude of anterior P2 support the results that there was no effect across all factors; Task (BF_{10} = 1.58), Saliency (BF_{10} = 1.51), Hemisphere (BF_{10} = 0.61), Task, and Saliency (BF_{10} = 0.25), Task, and Hemisphere (BF_{10} = 0.26), Saliency and Hemisphere (BF_{10} = 0.03), Task, Saliency and Hemisphere (BF_{10} = 0.04) see evidence from comparisons of posterior distributions in Appendix 1, Figures 33a,34a,35a,36a,37a,38a,39a).

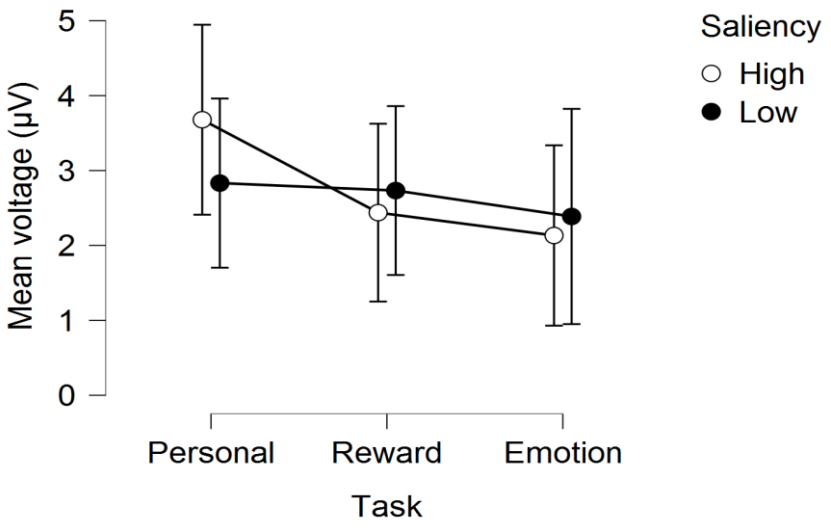

Figure 13. Mean anterior P2 amplitude for Saliency (High/Low) in Task (personal, reward and emotion) (SD are displayed in the error bars).

The relationship between Self- Reward- and Emotion-bias for anterior P2 amplitude was analysed using a PPMCC (*two-tailed*) (correlation results are displayed in Table.15).

Table 15

Correlation results between Self- Reward and Emotion-bias in anterior P2 amplitude(μV). Significant differences between pairings are marked with '*'.

	r	*p*	BF_{10}
Self- and Reward-bias	-.64	.003*	15.98
Self- and Emotion-bias	-.18	.45	0.36
Reward- and Emotion-bias	.07	.77	0.30

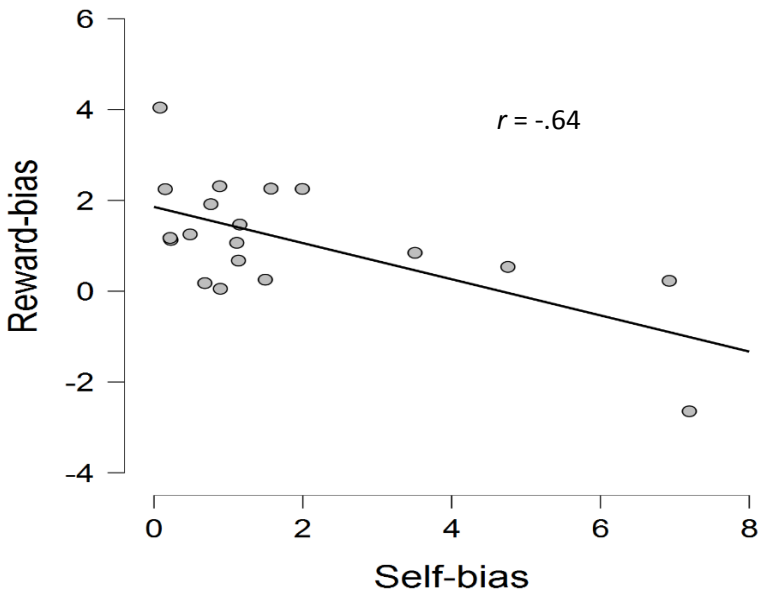

Figure 14. Self-bias on Reward-bias in anterior P2 amplitude. This figure demonstrates a moderate negative relationship between Self- and Reward-prioritization effects for anterior P2 amplitude.

3.1.3.6. Posterior P2 amplitude

Data for posterior P2 amplitude for the high saliency condition in the personal-task (Self) was significantly non normal and therefore violated normality assumptions. However skewness and kurtosis figures were all relatively small (Byrne, 2010; Hair, 2010). All other data for posterior P2 amplitude were all were all significantly normal**.** (Descriptive statistics for posterior P2 amplitude are displayed in Table.16).

Table 16

Mean and SD for posterior P2 amplitude(μV) for all conditions in personal- reward- and emotion tasks.

	Self	Stranger	£8	£2	Happy	Neutral
Mean	1.52	3.01	0.92	0.93	1.85	2.73
Std. Deviation	3.71	3.24	3.22	3.04	4.37	3.86

Posterior P2 amplitude was analysed with a 3 (Task) x2 (Saliency) rm-ANOVA. There was a significant main effect of Task [F (2,36) = 4.43, p = .02, η_p^2 = 0.20] and a significant main effect of Saliency[F (1,18) = 17.86, p =.02, η_p^2 = *0.27*], posterior P2 amplitude was weaker in the personal task for high saliency (Self) (M= 1.52, SD=3.71) compared with low saliency (Stranger), (M =3.01, SD = 3.24), however there was no significant interaction between Task and Saliency [F (2,36) = 1.91, p =.16, η_p^2 = 0.10].

Furthermore a Bayesian rm-ANOVA performed on posterior P2 amplitude supports the alternative hypothesis for the effect of Task (BF_{10} = 9.05) (i.e., that there will be a difference in amplitude of posterior P2 between the personal, reward and emotion tasks) and supports the alternative hypothesis for the effect of Saliency (i.e., that there will be a difference in amplitude for high saliency compared with low saliency) However, the evidence is classified as anecdotal (Jeffreys, 1961) (BF_{10} = 1.29). Bayes Factor support the alternative hypothesis for the interaction between task and saliency (BF_{10} = 14.45) (i.e., that there will be a difference in mean amplitude for high Saliency compared with low saliency between the tasks), see evidence from comparisons of posterior distributions in Appendix 1, Figures 40a,41a,42a,).

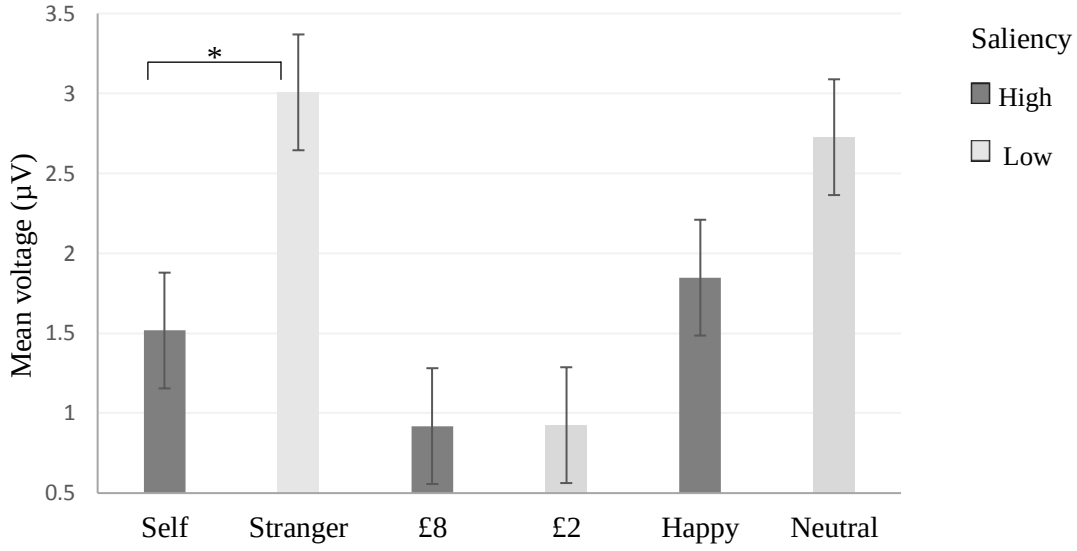

Figure 15. Mean posterior P2 amplitude for Saliency (High/Low) in Task (personal, reward and emotion) (standard deviations are displayed in the error bars). Significant differences are marked with '*'.

This figure demonstrates that mean posterior P2 amplitude in the personal task was larger for low saliency (stranger) compared to high saliency (self).

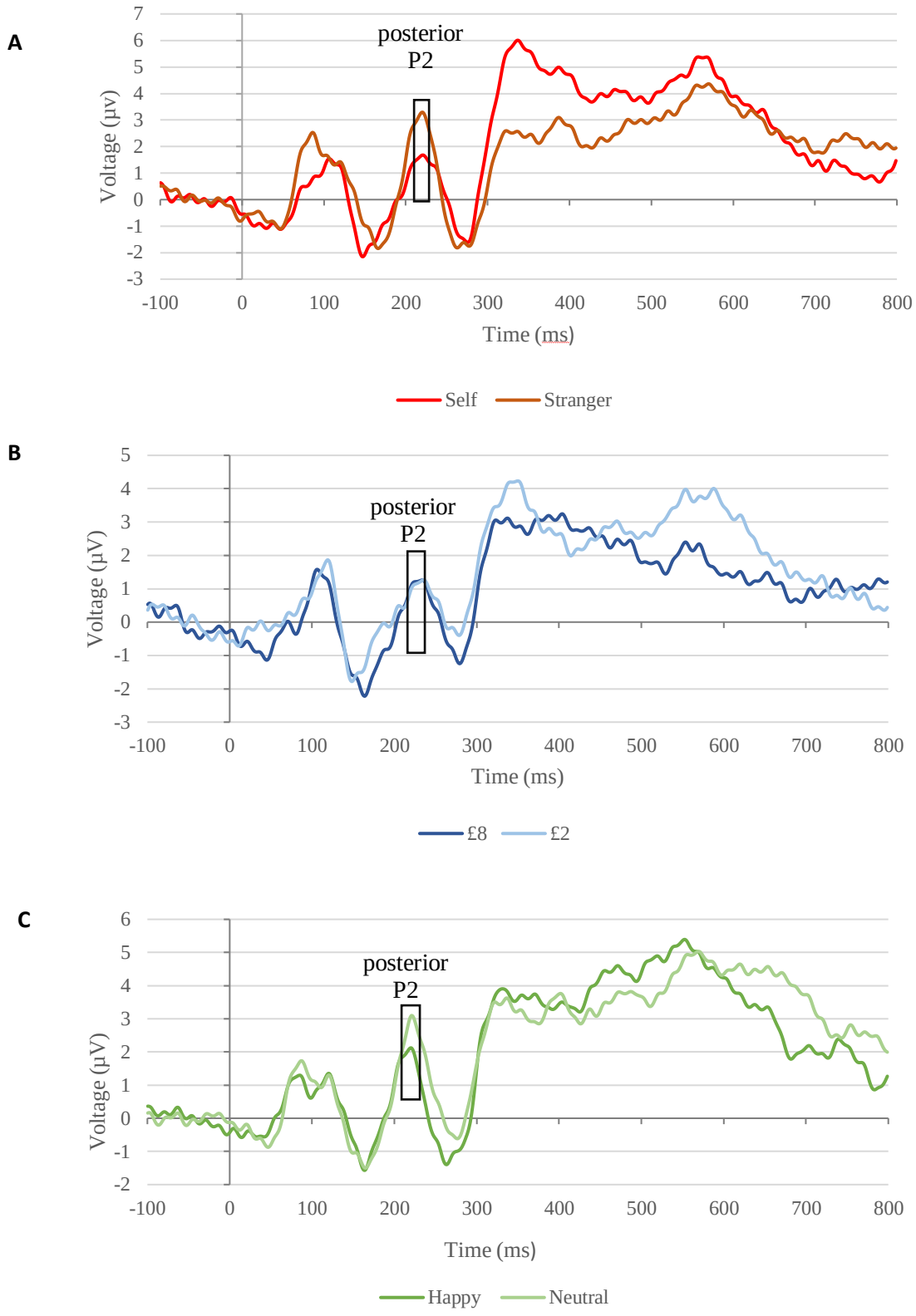

Figure 16. Waveforms for matched pairings in personal-(A) reward-(B) and emotion-tasks(C) for P2 amplitude(µV), calculated using the average of the channels Pz and POz.

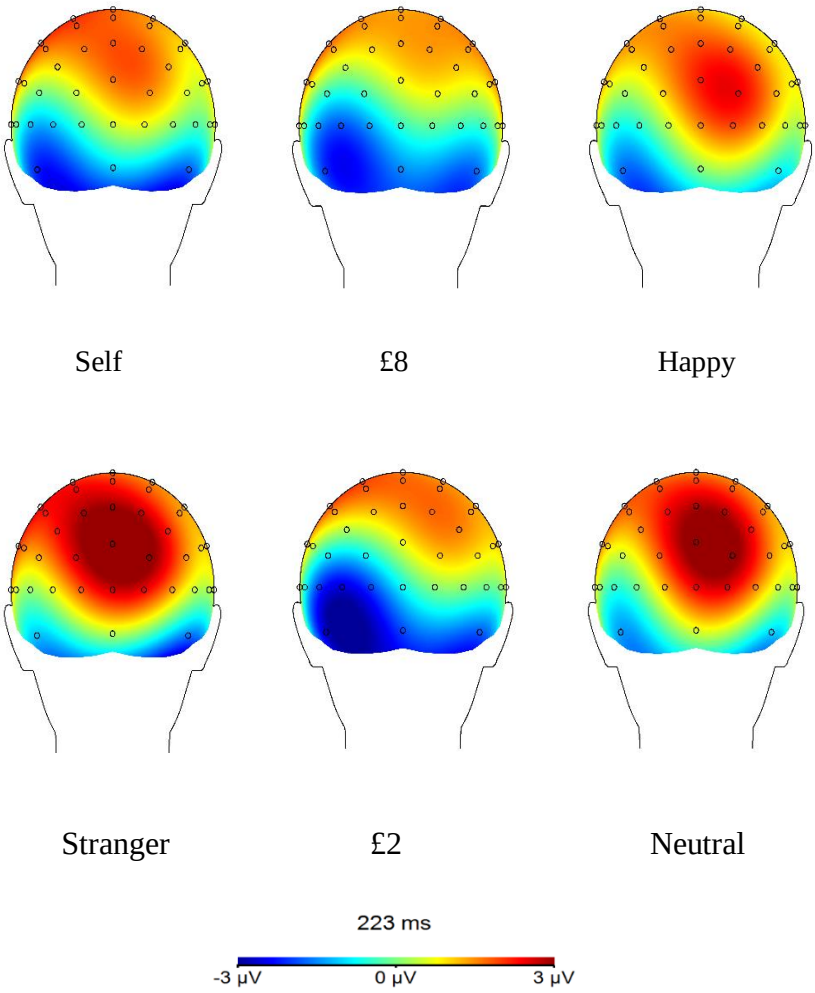

Figure 17. Topographic maps of match associations in all conditions for posterior P2 amplitude (213-233ms).

The relationship between Self- Reward- and Emotion-bias for posterior P2 amplitude was analysed using a PPMCC (*two-tailed*) (correlation results are displayed in Table.17).

Table 17

Correlation results between Self- Reward and Emotion-bias in posterior P2 amplitude(μV).

	r	*p*	BF_{10}
Self- and Reward-bias	.10	.68	0.31
Self- and Emotion-bias	-.24	.32	0.45
Reward- and Emotion-bias	-.18	.47	0.36

3.1.3.7. Posterior P2 effect

Data for Posterior P2 effect for the high saliency condition in the personal-task (Self) and the emotion-task (Happy) was significantly non normal and therefor violated normality assumptions. However skewness and kurtosis figures were all relatively small (Byrne, 2010; Hair, 2010). All other data for posterior P2 effect were all were all significantly normal (Descriptive statistics for posterior P2 effect are displayed in Table.18).

Table 18

Mean and SD for posterior P2 effect for all conditions in personal- reward- and emotion tasks.

	Self	Stranger	£8	£2	Happy	Neutral
Mean	0.29	2.44	-0.81	-0.80	1.41	1.74
Std. Deviation	2.82	2.58	3.22	2.78	3.79	3.13

Posterior P2 effect was analysed using a 3 (Task) x2 (Saliency) rm-ANOVA. There was a significant effect of Task [F (2,36) = 12.55, p <.001, η_p^2 = 0.41],there was a significant

effect of Saliency [F (1,18) = 7.71, p = .01, η_p^2 = 0.30] and a significant interaction between Task and Saliency [F (2,36) = 5.10, p =.01, η_p^2 = 0.22].

Furthermore a Bayesian rm-ANOVA performed on posterior P2 effect supports the results of a significant effect of Task (BF_{10} = 22832.36) and significant effect of Saliency (BF_{10} = 1.05). Bayes Factor support the alternative hypothesis for the interaction between Task and Saliency (BF_{10} = 41840.91) (i.e., that there will be a difference in posterior P2 effect for high saliency compared with low saliency in the tasks), (see evidence from comparisons of posterior distributions in Appendix 1, Figures 56a,57a,58a,).

To test a significant main effect of Task a Post-Hoc test was carried out using the Bonferroni correction (α altered = .05/3) =.02 (rounded) and indicated that posterior P2 effect in the Personal-task compared with Reward task significantly differed (MDiff = 2.17, SE=0.53, t (18) = 4.13, p <.001) and the Reward-task compared with Emotion-task significantly differed (MDiff = -2.38, SE=0.53, t (18) = -4.52, p <.001).

To test a significant main effect of Saliency a Post-Hoc test was carried out and indicated that high saliency compared with low saliency significantly differed (MDiff = -0.82, SE=0.29, t (18) = -2.78, p =.01).

To test a significant interaction between Task and Saliency a Post-Hoc test was carried out using the Bonferroni correction (α altered = .05/15) =.003 (rounded) and indicated that high saliency in the Personal task (Self) compared with low saliency (Stranger) significantly differed (MDiff = -2.14, SE = 0.51, t (18) = -4.19, p =.002).There were no other significant pairings.

A paired samples t-test was conducted on Task for High and Low saliency and indicated that posterior P2 effect in the personal task for low saliency (Stranger) (M = 2.43, SD = 2.58) compared to high saliency (Self) (M= 0.29, SD=2.82) was significantly greater [t

(18) = 3.21, p = .001], high saliency in the personal-task (Self) (M = 0.29, SD = 2.82) compared to high saliency in the reward task(£8) (M= -0.81, SD=3.22) was significantly greater [t (18) =1.82, p = .04] and high saliency in the emotion-task (Happy) (M = 1.41, SD = 2.99) compared to high saliency in the reward task(£8) (M= -0.81, SD=3.22) was significantly greater [t (18) =3.08, p = .003].There were no other significant pairings between Task and Saliency.

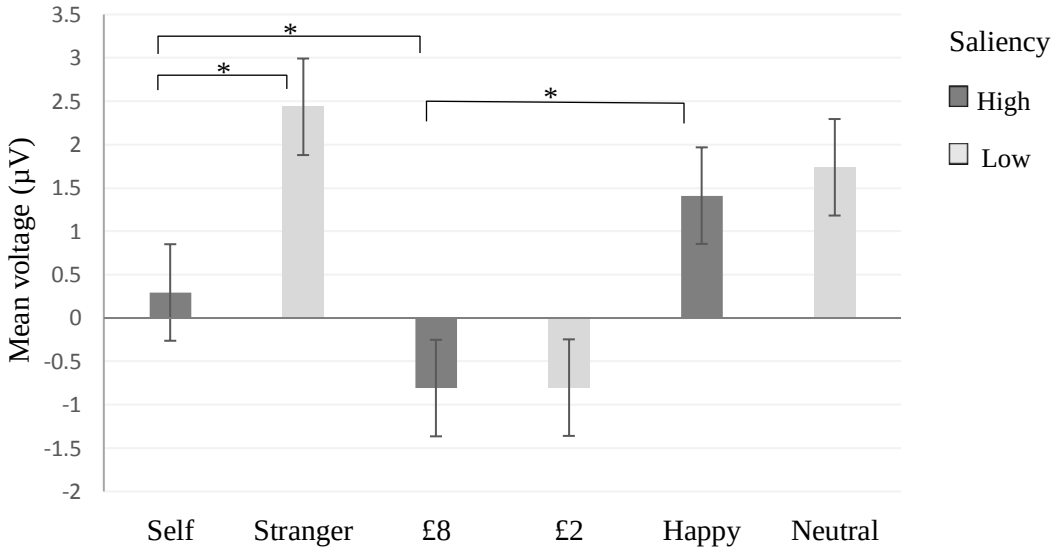

Figure 18. Mean posterior P2 effect for Saliency (High/Low) in Task (personal, reward and emotion) (SD are displayed in the error bars). Significant differences are marked with '*'.This figure demonstrates that posterior P2 effect was greater for low saliency (Stranger) compared to high saliency (Self) in the personal task and greater for high saliency in the personal- and emotion-task (Happy) compared to high saliency (£8) in the reward task.

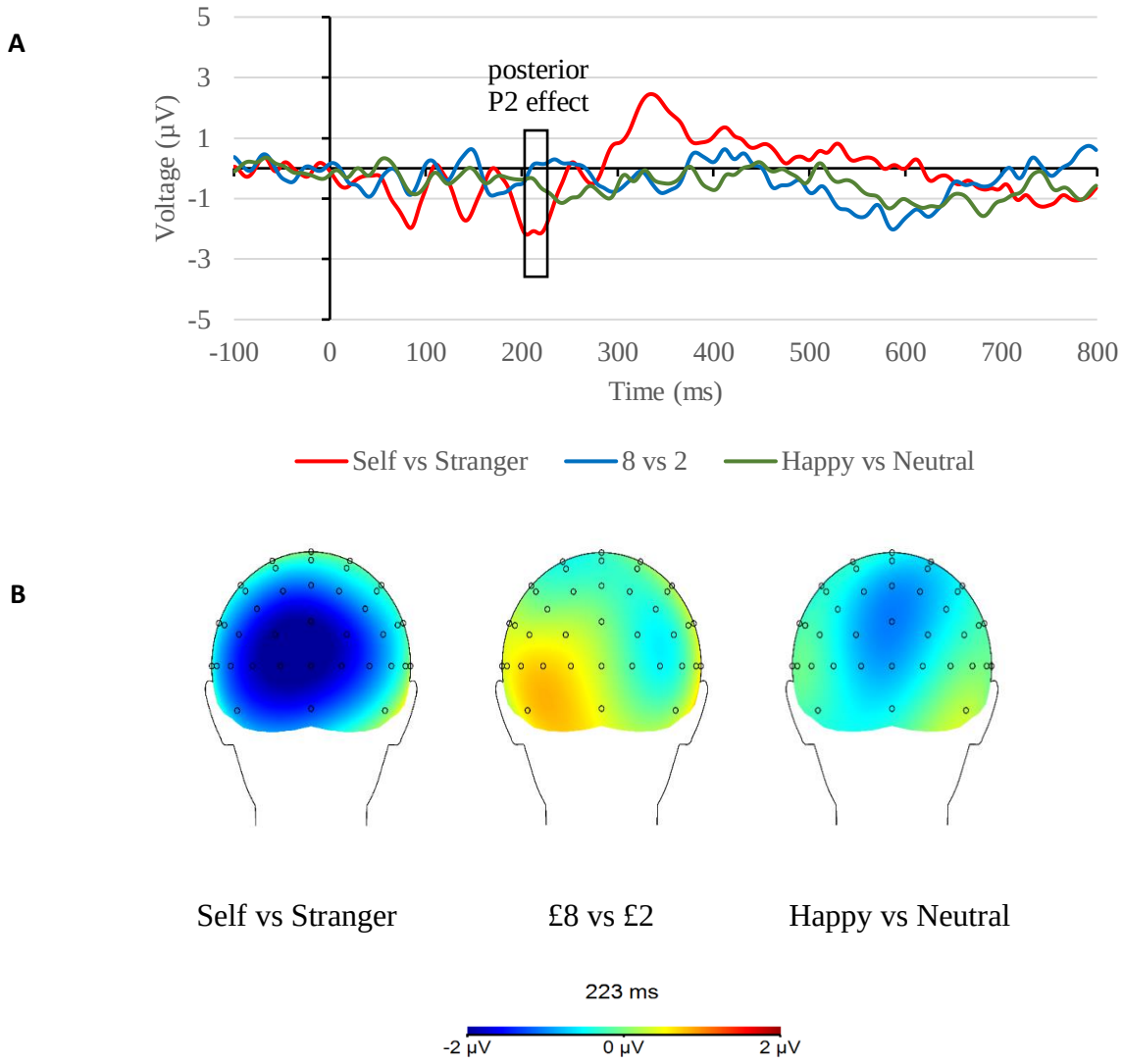

Figure 19. Waveforms(A) and Topographic maps(B) of differences between match pairings for all conditions for posterior P2 effect (203-223ms), calculated using the average of channels PO3, POz, PO4, O1, Oz and O2.

The relationship between Self- Reward- and Emotion-bias in posterior P2 effect was analysed using a PPMCC (*two-tailed*) (correlation results are displayed in Table.19.)

Table 19

Correlation results between Self- Reward and Emotion-bias in posterior P2 effect. Significant differences between pairings are marked with '*'.

	r	*p*	BF_{10}
Self- and Reward-bias	.56	.01*	5.08
Self- and Emotion-bias	-.18	.45	0.34
Reward- and Emotion-bias	.16	.52	0.29

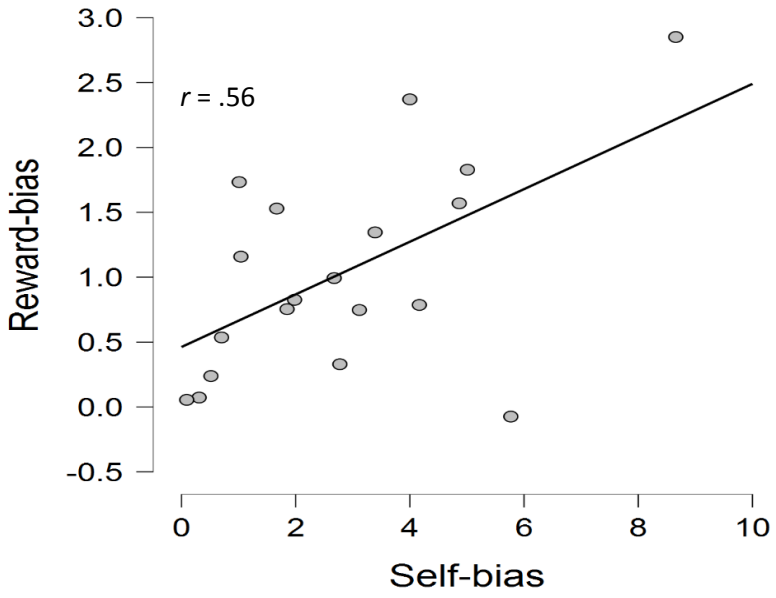

Figure 20. Self-bias on Reward-bias in posterior P2 effects. This figure demonstrates a moderate positive relationship between Self- and Reward-prioritization effects for posterior P2 effects.

3.1.3.8. Posterior N2 amplitude

Data for Posterior N2 amplitude in left hemisphere for high saliency (£8) in the reward-task were significantly non normal and therefor violate normality assumptions. However skewness and kurtosis figures were all relatively small (Byrne, 2010; Hair, 2010). All other data for posterior N2 effect were all were all significantly normal. (Descriptive statistics for posterior N2 amplitude are displayed in Table.20).

Table. 20

Mean (SD in brackets) posterior N2 amplitude(μV) in Left- (LH) and Right-hemisphere (RH) for all condition in personal- reward- and emotion tasks.

	LH	RH
Self	-2.45(2.51)	-2.03(3.03)
Stranger	-1.73(2.31)	-1.92 (2.48)
£8	-2.25 (2.96)	-2.56 (2.98)
£2	-3.28 (3.29)	-2.47 (2.89)
Happy	-2.47 (2.48)	-2.05 (3.14)
Neutral	-2.0 (2.72)	-1.26 (3.04)

Posterior N2 was analysed using a 3 (Task) x2 (Saliency) x2 (Hemisphere) rm-ANOVA. There was a significant interaction between Task, Saliency and Hemisphere (degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .75$) [F (1.50,27.04) = 3.94, p =.04, η_p^2 = 0.18] all other effects were not significant; Task [F (2,36) = 2.4, p = .11, η_p^2 = 0.12], Saliency[F (1,18) = 1.0, p =.33, η_p^2 = *0.05*], Hemisphere [F (1,18) = 0.37, p =.55, η_p^2 = *0.02*], Task and Saliency[F (2,36) = 2.9, p =.07, η_p^2 = *0.14*],

Task and Hemisphere [F (2,36) = 0.6, p =.56, η_p^2 = *0.32*], Saliency and Hemisphere [F (1,18) = 1.8, p =.19, η_p^2 = 0.09].

Furthermore a Bayesian rm-ANOVA performed posterior N2 amplitude supports results that there was no effect of; Task (BF_{10} = 0.81) Saliency (BF_{10} = 0.19) , Hemisphere (BF_{10} = 0.31) and no interaction between; Task and Saliency (BF_{10} = 0.16), Task and Hemisphere(BF_{10} = 0.25), Saliency and Hemisphere (BF_{10} = 0.06). Bayes Factor failed to support the alternative hypothesis for the interaction between Task and Saliency and Hemisphere (BF_{10} = 0.05) (i.e., that there will be a difference in amplitude in Left/Right hemisphere for high Saliency compared with low saliency between the tasks), see evidence from comparisons of posterior distributions in Appendix 1, (Figures 43a,44a,45a,46a,47a,48a and 49a.).

To test a significant main effect for Task, Saliency and Hemisphere a Post-Hoc test was carried out using the Bonferroni correction (α altered = .05/66) =.00076 (rounded). However Post-Hoc analysis did not indicate any significant pairings for posterior N2 amplitude between Task, Saliency and Hemisphere.

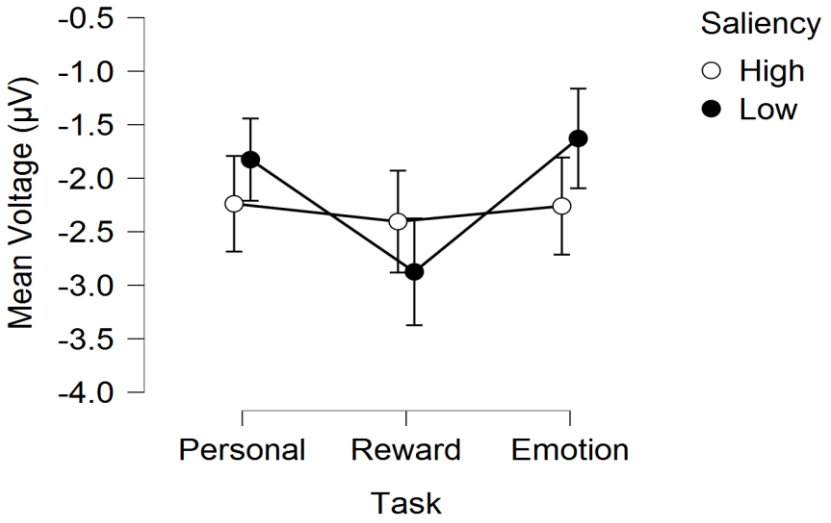

Figure 21. Mean posterior N2 amplitude for Saliency (High/Low) in Task (personal, reward and emotion) (standard deviations are displayed in the error bars).

The relationship between Self- Reward- and Emotion-bias for posterior N2 amplitude was analysed using a PPMCC (two-tailed) (correlation results are displayed in Table.21)

Table 21

Correlation results between Self- Reward and Emotion-bias in posterior N2 amplitude(μV).

	r	*p*	BF_{10}
Self- and Reward-bias	.12	.63	0.32
Self- and Emotion-bias	-.18	.46	0.37
Reward- and Emotion-bias	.-.10	.69	0.31

3.1.3.9. P3 amplitude

Data for P3 amplitude were all significantly normal and therefore satisfy normality assumptions that the data is normally distributed (Descriptive statistics for P3 amplitude are displayed in Table.22).

Table 22

Mean and SD for P3 amplitude(μV) for all conditions in personal- reward- and emotion tasks.

	Self	Stranger	£8	£2	Happy	Neutral
Mean	5.35	2.18	2.42	3.52	3.51	2.96
Std. Deviation	4.28	3.86	3.50	3.59	5.33	4.06

P3 amplitude was analysed with a 3 (Task) x2 (Saliency) rm-ANOVA. There was a significant interaction between Task and Saliency [F (2,36) = 9.3, p <.001, η_p^2 = 0.34] all other effects were not significant ; Task [F (2,36) = 0.44, p = .05, η_p^2 = 0.19] Saliency [F (1,18) = 4.26, p =.33, η_p^2 = *0.05*]. Furthermore a Bayesian rm-ANOVA performed on P3 amplitude supports the results of no significant effect of Task (BF_{10} = 0.14), nor Saliency (BF_{10} = 0.59). However Bayes Factor failed to support the alternative hypothesis for the interaction between Task and Saliency (BF_{10} = 0.08) (i.e., that there will be a difference in P3 amplitude for high Saliency compared with low saliency between the tasks), see evidence from comparisons of posterior distributions in Appendix 1, Figures 50a,51a,52a,).

To test a significant interaction between Task and Saliency a Post-Hoc test was carried out using the Bonferroni correction (α altered = .05/15) =.003 (rounded) and indicated that P3 amplitude in the personal-task for high saliency (Self) compared with low saliency (Stranger) significantly differed (MDiff = 3.17, SE=0.72, t (18) = 4.43, p <.001).

A paired samples t-test was conducted on mean amplitude for Saliency for Task (Personal; Self versus Stranger, Reward;£8 versus £2,Emotion;Happy versus Neutral) and indicated that P3 amplitude in the personal task for high saliency (Self) (M= 5.35, SD=4.28) compared to low saliency (Stranger) (M = 2.17, SD = 3.86) was significantly greater [t (18) = 3.82, p < .001]. There were no other significant pairings between Task and Saliency.

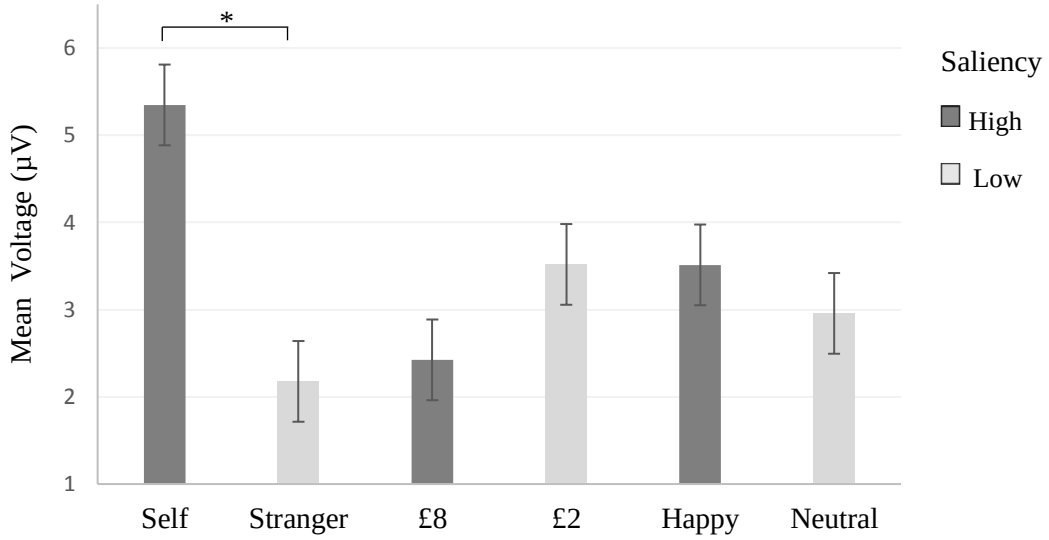

Figure 22. Mean P3 amplitude for Saliency (High/Low) in Task (personal, reward and emotion) (SD are displayed in the error bars) significant differences are marked with '*'.

This figure demonstrates that P3 amplitude was greater for high saliency (self) compared to low saliency (stranger) in the personal task.

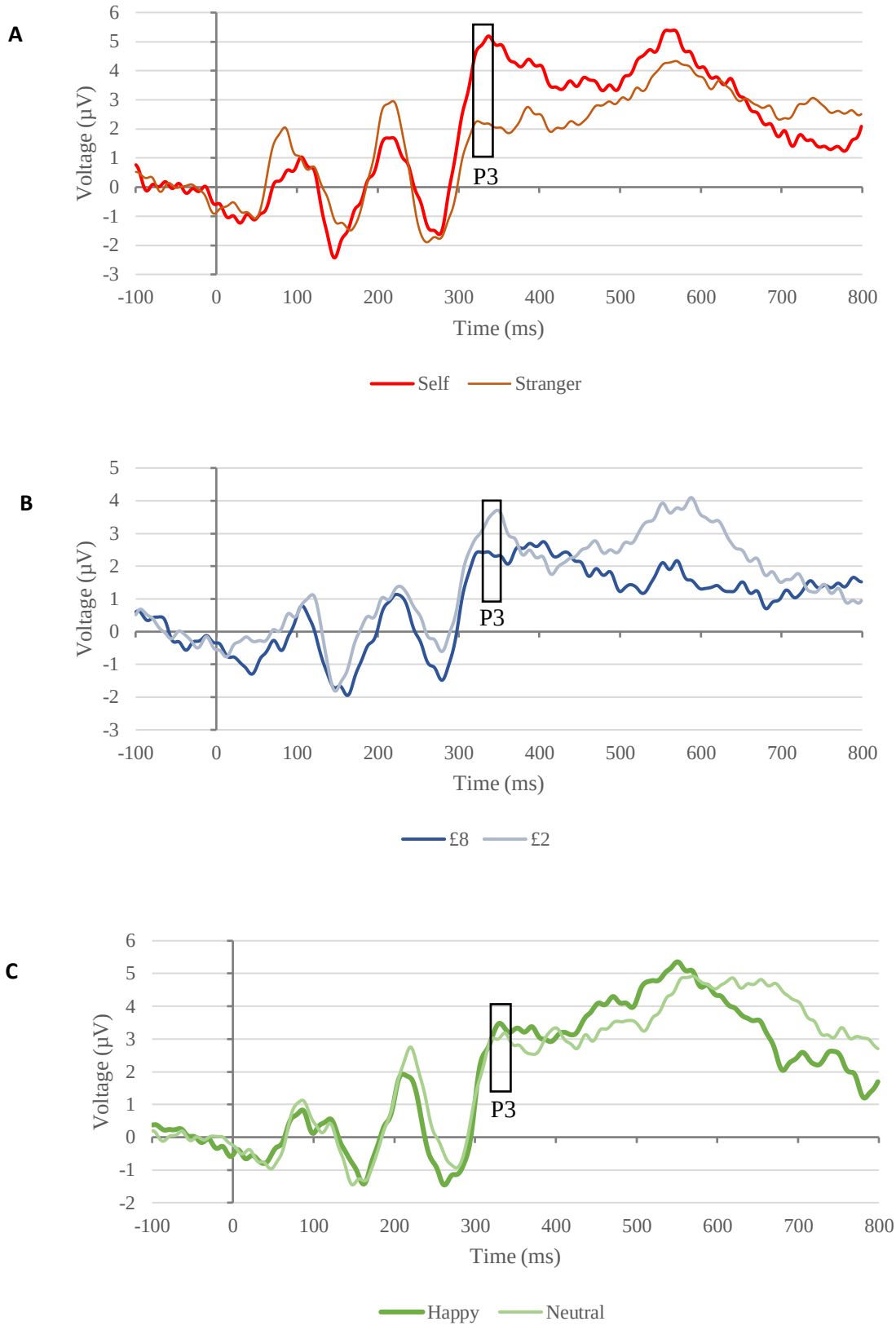

Figure 23. Waveforms for matched pairings in Personal-(A), Reward-(B) and Emotion-tasks (C) for P3 amplitude(326-356ms), average of channels Pz,P1,P2,POz and CPz

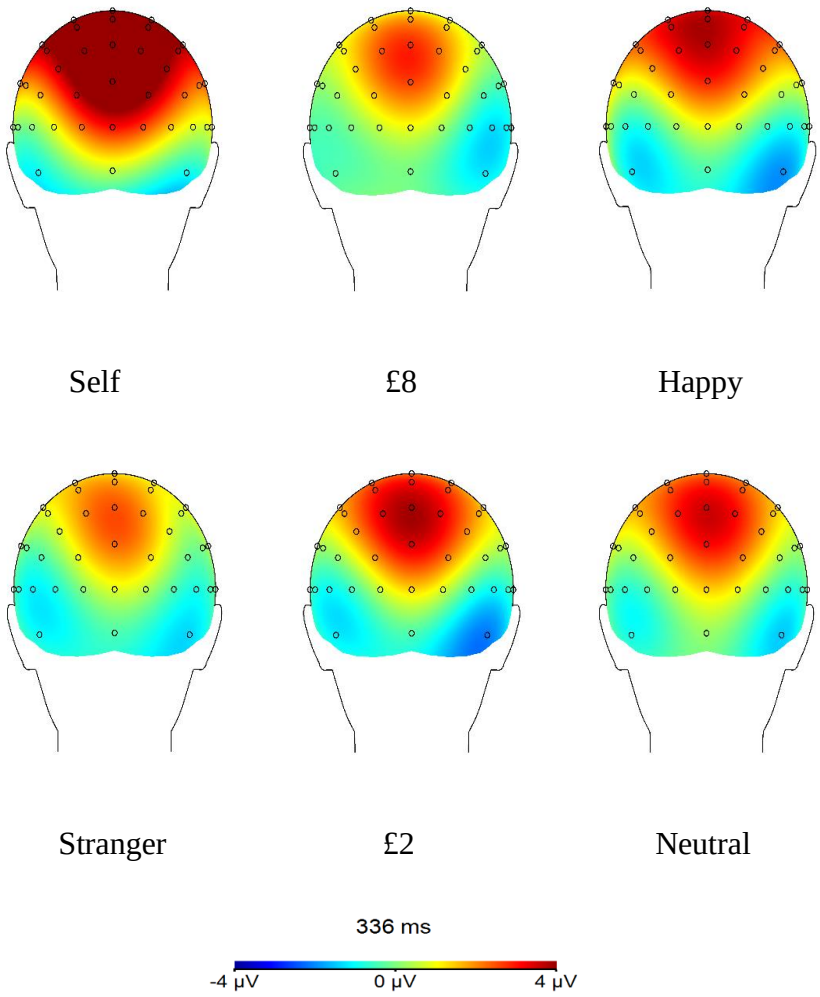

Figure 24. Topographic maps for all task conditions for P3 amplitude (326-356ms).

The relationship between Self- Reward- and Emotion-bias in P3 amplitude was analysed using a PPMCC (*two-tailed*) (correlation results are displayed in Table.23

Table 23

Correlation results between Self- Reward and Emotion-bias in P3 amplitude(µV).

	r	*p*	BF_{10}
Self- and Reward-bias	.27	.26	0.52
Self- and Emotion-bias	.19	.44	0.38
Reward- and Emotion-bias	.28	.24	0.54

4. Discussion

The current research investigated the relationship between basic effects of self-reference, reward and emotion on perception using an associative matching procedure and measuring temporal characteristics of brain activity. The associative matching procedure allows measuring the effects of self-relevance, reward and emotion on the same scale enabling direct comparisons between these effects. Using this procedure enabled us to go beyond previous research that used different experimental paradigms to assess these effects (e.g. Banich and Floresco, (2019); Watanabe, Sakagami, and Haruno, (2013)).

4.1. Behavioural Findings

In line with previous literature we found a prioritization effect for self and emotion evident in an advantage of performance (faster response times and better accuracy) for correct shape-label pairings with self compared to stranger and happy compared to neutral labels. The data supports previous findings that stimuli associated with self-relevance and positive emotions gain priority in processing. Explanations as to why these prioritization effects occur propose that they are governed by specific cognitive mechanisms, for example, Humphreys and Sui, (2015), suggested attentional mechanisms underlying these effects and pointed to a specific neural network supporting the effects of self. In addition the effects of positive-emotion has also be linked to attentional as well as motivational and memory mechanisms (Dolcos et al., 2020).

Results indicate there was not an advantage in performance between high- and low-reward labels and a prioritization effect was not found for high-reward. This contradicts previous reports that stimuli associated with high-reward gain more speed and accuracy in processing compared to low because it is considered more salient (Sui et al., 2012). However,

this finding is in line with research demonstrating that people process the highest and the lowest values at a similar processing rate, for example, Yankouskaya et al., (2018), reported no RT differences between stimuli associated with high (9x) and low (1x) reward.

Somewhat similar results were reported in previous studies on reward processing using a different experimental paradigm, for example, previous studies reported biased memory for the highest and the lowest outcomes associated with reward (Klingberg, 2010; Madan & Spetch, 2012) and more recent research linked the memory bias for reward with decision making, such as Madan et al., (2014), who argued that the memory bias from the past experience, results in overweighting the largest gains and largest losses, leading people to seek for relative gains rather than relative losses. Furthermore, in a task where monetary reward anticipation was linked to incidental objects, neural patterns related to reward experiences were re-expressed on later exposure to stimuli and reactivation strongly correlated with the behavioural performance (Wimmer & Buchel, 2016).

We predicted that there would be a relationship found between prioritization effects. This was based on behavioural similarities found for these effects in that they have all been shown to modulate perception and previous neurological evidence that demonstrates activation of the same brain areas such as the amygdala and ventromedial prefrontal cortex (vmPFC) for the processing of these effects (Pessoa, 2010; Sui, Chechlacz, Rotshtein, & Humphreys, 2015) . In the present study, a moderately positive relationship was found between the advantages in accuracy performance for self and happy labels. This indicates commonalities in the perceptual functioning for self-reference and positive emotion. Which therefore suggests that these effects might share cognitive mechanisms that operate together for basic processing.

However findings are inconsistent with Stolte et al., (2017), whereby no relationship was found between self and emotion and suggests that self- and emotion-processing occur

separately. Arguably the inconsistencies between results could be due to methodological differences. Stolte et al., (2017), used graphically complex faces as opposed to worded labels in the current study, which could have arguably effected processing time because there were more features to visually examine. Furthermore, Stolte et al., (2017), reported that self-relevance produced biases of slightly larger magnitude compared to positive emotion, and suggests that this was most likely due to the complex faces being more difficult to discriminate than the self-other labels. In comparison in our current study the magnitudes between self and emotion bias were relatively similar.

Most recent neurological evidence provides support that the cognitive processes for self-relatedness and emotion are dissociable, for example, Moran, Macrae, Heatherton, Wyland, and Kelley, (2006), demonstrated that self-relatedness is linked with activity in medial prefrontal cortex (mPFC) and that an increase in activity in this area occurred independent of the emotionality of stimuli, whereas positive compared to negative emotionality of self-relevant information was conveyed by activity in the ventral anterior cingulate cortex (vACC). In extension, Northoff et al., (2009), detected differential parametric modulation for self-relevance compared with emotional valence in the dorsomedial prefrontal cortex (dmPFC), whereas neural activity for self-relevance and emotions in lower subcortical regions were parametrically modulated in the same direction. This therefore highlights that both overlap, and segregation occur between the cognitive processing for self-relatedness and positive emotion and demonstrates that the dmPFC plays a vital role in the distinguishability between them.

Commonalities were also found in the present study between advantages in response time for high-reward (£8) and happy labels, a strong positive relationship was found between bias in response-time for high-reward and positive-emotion, which indicates that the processes for reward and emotion share the same cognitive mechanisms. These findings

support neurological research that indicate overlaps for the processing of both reward and emotion (Pessoa, 2010). For example Lin et al., (2012) observed overlaps in the vmPFC for the cognitive processing of monetary rewards and smiling faces. The interaction of these processes is suggested to aid decision making, which is modulated by learning, in that the values assigned to stimuli help to predict outcomes and reduce prediction errors. In short we become programmed to respond to the most rewarding outcome because it is considered to yield a more successful outcome.

No relationship was found between prioritization effects for self and reward consistent with findings by Yankouskaya et al., (2018). In line with Northoff and Hayes, (2011), findings suggest that the cognitive processes for self and reward (notably for low-level stimuli) are distinct but operate in parallel. Findings could therefore suggest that cognitive processes for self- emotion- and reward-biases operate together for basic, low-level processing but distinction occurs for more complex high-level processing, consistent with neurological evidence of both overlap and segregation for these processes (Bayer, Ruthmann, & Schacht, 2017; Lin et al., 2012; Northoff et al., 2009).

4.2. Electrophysiological Findings

It was predicted that the time courses for self- reward- and emotion-prioritization effects will reflect early visual processing and attentional capture, evident in enhanced amplitudes of P1,N1,P2 andN2 components for the processing of shape-label matches with labels; self compared to stranger, high-reward (£8) compared to low (£2) and happy compared to neutral.

Current results indicate a significant decrease in posterior P2 amplitudes (223ms) for the processing of shape-label matches for self compared with stranger labels, however no significant effect was found for emotion/reward stimuli. This reflects higher-order perceptual

processing for self-relevance, modulated by attention (Lijffijt et al., 2009).Findings therefore support predictions of early automatic attentional processing for self-relevance because they are considered highly salient and are consistent with reports that self-other discrimination occurs almost automatically (Fields & Kuperberg, 2012),echoed by traditional views that the "self" reflects a higher-order process (Gennaro, 2005).

Furthermore there was a significantly greater amplitude of P300 (336ms) for self-relevant stimuli. The P300 is linked to engaging of attention and decision making (Polich, 2007), therefor findings suggests that the processing of self reached a higher level of processing before reward and emotion. This finding indicates that the processing for self-relevance is faster than reward/emotion processing because it is less demanding on cognitive workload. Which would also explain why response times were overall faster for self-relevant stimuli compared with the other conditions.

Current results indicate a significantly stronger magnitude in P1effect for low-saliency stimuli (stranger) compared to high-saliency (self) in the personal task and for high-saliency in the emotion-task (happy) compared with high-reward (£8). P1 has been linked to visual-spatial attention and perceptual analysis (Luck, Heinze, Mangun, & Hillyard, 1990). Findings imply that less attentional resources are required for the processing of self-relevance compared to stranger and suggests differential cognitive processes are involved for high-reward compared to positive-emotion. This is further evidence of automatic capture in attention for self-relevance and supports previous reports of dissociable processes for reward and emotion (Banich & Floresco, 2019).

Furthermore a significantly greater magnitude in posterior P2 effects was found in the present study for low-saliency (Stranger) compared to high-saliency (Self) in the personal task and greater for high-saliency in the personal- and emotion-task (Happy) compared to

high-reward (£8).Which therefore suggests that self-reference and positive-emotion modulate attentional processing at a different stage compared high-reward.

It was predicted that there would be a relationship between the temporal properties for self-reward and emotion-prioritization effects. Current findings indicate similarities for the temporal characteristics of brain activity for self- and reward-prioritization effects, we found a significant moderate negative relationship for anterior P2 amplitude, and a significant moderate positive relationship for posterior P2 effects between self- and reward-prioritization effects. However no significant relationship was found between these and emotion-prioritization effects, which supports Zhou et al., (2017), that suggests that time-courses for self-reference emerges earlier than emotion and interacts at a later processing stage at higher-cortical level.

Findings advocate Northoff and Hayes, (2011), Parallel Processing Model which suggests that the processing of self and reward are inextricably linked. The anterior P2 component has been linked to working memory and cognitive control (Wolach & Pratt, 2001),whereas the posterior P2 is considered an index for attentional modulation of visual processing (Fields & Kuperberg, 2012). Interestingly the P2 is considered to be part of a cognitive matching system that compares sensory processing with memory, that draws upon previous experience and learning linked with sensory inputs, which in turn modulates decision making (Freunberger, Klimesch, Doppelmayr, & Holler, 2007).

Therefore, in consideration to previous reports that self-reference enhances binding of information (Sui & Humphreys, 2015),current findings propose that self-processing modulates reward-processing and enhances the binding of information at differential cortical levels of processing and that these processes are subject to top-down control.

Our electrophysiological findings are slightly different from our behavioural findings whereby no relationship was found between self and reward, but a positive relationship was found between self and emotion, and between reward and emotion, this could indicate that the cognitive processes for self and reward interact at early stage but are distinct in later stages, and that emotion processing operates in parallel with self and reward in early processing and is modulated by them in late processing.

Findings therefore suggest that self and reward are processed on a self-reward continuum that benefits from an interactive relationship in a hierarchical fashion and that emotion interacts with this continuum at later cortical processing.

4.3. Significance of research

This is the first attempt to examine the time courses underlying self- reward- and emotion-prioritization effects, using a robust experimental method that measures all three effects along the same scale. The research will therefore provide a significant contribution towards developing a clear explanation of how social factors (self, reward and emotion) influence perception. The more we know about how these factors are processed and how they relate each to other the better we can refine our approach to treating and diagnosing a wide range of disorders that have implications within these factors. For example, clinical research for individuals with depression, a disorder where people can have an negatively altered sense of self and diminished emotional processing (Sui & Gu, 2017). If neurological mechanisms for self and emotion share the same brain areas then we can affect, say emotions by facilitating self-processing.

The breakdown of the functioning of self-, emotion- and reward-processing also share similarities in treatment approaches such as cognitive behavioural therapy which is used to

treat individuals with depression and is also used for individuals with gambling addictions. Interestingly one of the emerging themes from research on individuals with depression is the suggestion that these individuals show abnormalities in reward processing, especially in the context of stress (Banich & Floresco, 2019). A recent emerging approach by Zotev, Mayeli, Misaki, and Bodurka, (2019), has adopted emotion self-regulation training for patients with depression by using an induced happy emotion task and monitor the efficiency of the treatment with fMRI and EEG neurofeedback.

It could therefore be suggested that the current research could help monitor the efficiency of therapeutic interventions and measure self-, reward- and emotion-biases before and after intervention techniques.

4.4. Limitations and future research

One limitation of the current study is the small sample size, external factors beyond the researchers control (i.e. abrupt government restrictions on public interaction),meant that testing had to be cut short and we were not able to achieve the originally planned sample size. Another limitation is that for the reward task small monetary values were used (£8/£2) and for some £8 might not be considered a reward, future research should there for consider using other extrinsic rewards such as winning a game of sports or a tasty meal, to see if they elicit similar responses to monetary rewards and are processed in the same way.

Other limitations to be considered are individual differences and culture as potential influencing factors in self- reward- and emotion-biases. Electrophysiological correlates have demonstrated culture-sensitive cognitive mechanisms in both high and low level processing (Han & Northoff, 2008) and recent research has reported cultural differences in attention and memory processing and the magnitude expressed for self-relevance (Liu et al., 2015), reward-prioritization (Telzer, Qu, & Lin, 2017), and emotion-bias (Tsai & Qu,

2018). For example, a cross cultural comparison by Jiang et al., (2019) utilized Sui et al's., (2012), perceptual matching task to explore cultural differences in bias toward processing of self-relevance. Findings demonstrated that individualistic western cultures that favour autonomous views of oneself, exhibit much higher self-bias compared to collectivist eastern cultures that tend to consider the "self" as a group identity. This therefore highlights the modulation of culture in self-bias for perceptual matching.

Furthermore, Tompson et al., (2018), demonstrated cultural variations in emotion-bias are linked with the dopamine D4 receptor gene (DRD4), in that East Asian carriers of DRD4 experienced weaker positive emotion bias whereas European American carriers showed a stronger positive emotion bias, compared with non-carriers. Interestingly the same receptor gene has also been shown to have cultural implications in reward-processing, for example, Glazer, King, Yoon, Liberzon, and Kitayama, (2020), explored the modulation of DRD4 on reward-prioritization and cultural learning, using EEG to record East Asian and European American participants electrophysiological responses during a gambling task. Findings revealed European DRD4 carriers (compared with East Asian), exhibited a stronger positive activation in ERPs involved in top-down attention (frontal P3) and decision making towards reward processing.

Future research could therefore benefit from extending the current study in a cross-cultural approach to explore potential cultural variations in the temporal characteristics for the processing of self- reward- and emotion-biases. Which would ultimately enhance our understanding of the relationship.

4.5. Conclusion

The present study takes the lead on current literature by being the first study to use a novel approach to compare the temporal characteristics of self- reward- and emotion-

prioritization effects. We take a step closer towards understanding how the processes between self- reward- and emotion-biases are related. Findings suggest that the time courses for self emerges slightly earlier than emotion and reward, but they share similarities in time courses in later processing, which indicates that the self is highly prioritized and plays a modulatory role between emotion- and reward-processing.

In light of previous neurological reports that suggest both segregation between these processes in brain areas such as the mPFC and the vACC (Moran et al., 2006),and modulation between them in areas such as the vmPFC (Northoff et al., 2006). A vital step forward would be to examine where in the brain distinction and overlap in processing of self reward and emotion occur. Future research should therefore consider using fMRI to measure brain activity during the associative matching-tasks used in the current study. This would build upon previous neurological evidence using a robust experimental design in a comparable approach and add a valuable piece to the puzzle.

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Appendix

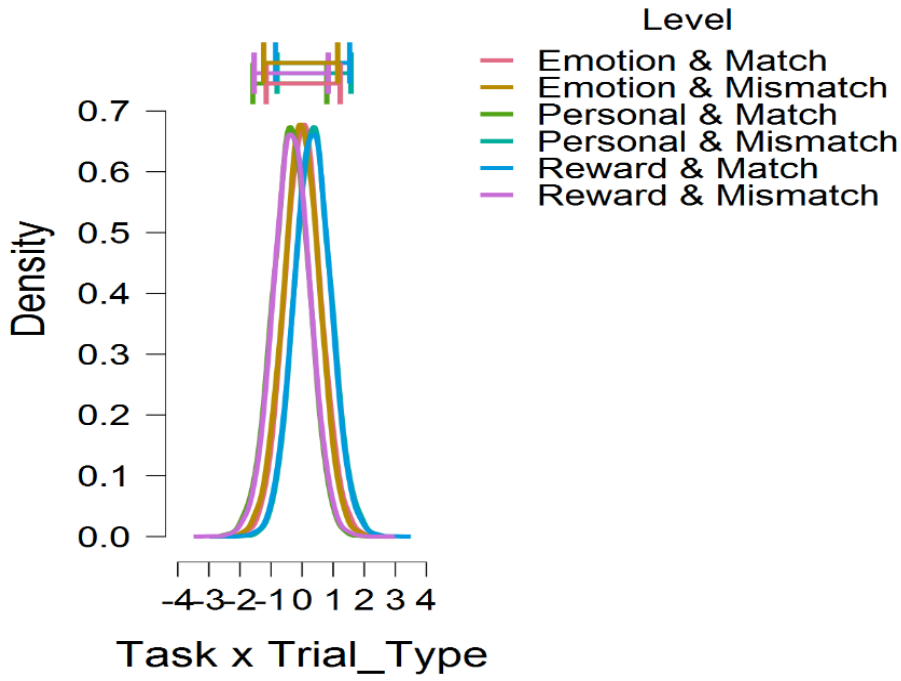

***Figure 1a*:** Average posterior probability distribution for Task (Personal, Reward and Emotion) and Trial Type (Match and Mismatch) for accuracy performance. This figure demonstrates that the posterior distribution for Trial Type are almost overlapping each other indicating that there is no significant difference in the posterior distribution for the Trial Type.

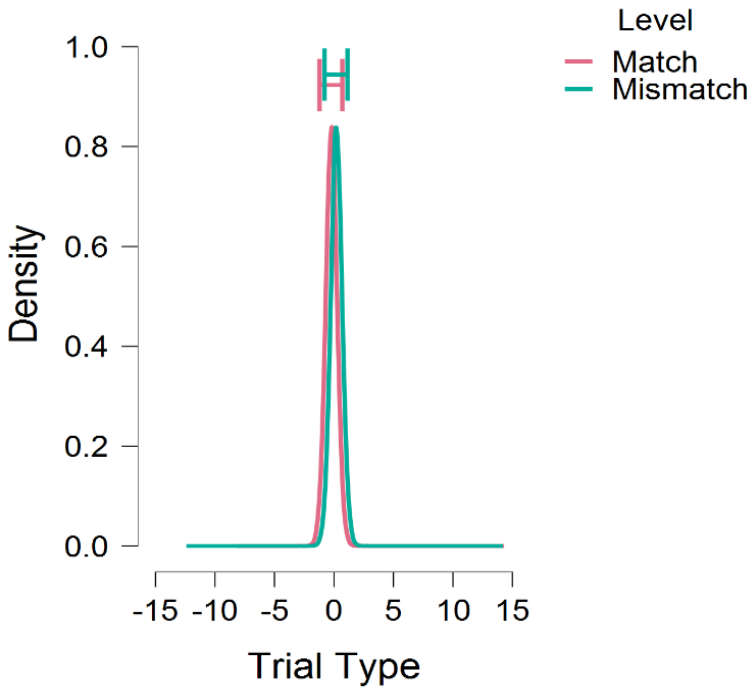

Figure 2a: Average posterior distribution for Trial Type (Match and Mismatch) for accuracy performance. This figure demonstrates that there is a big overlay between posterior distributions for Trial Type thus indicating that there is no significant difference in the posterior distribution for the Trial Type.

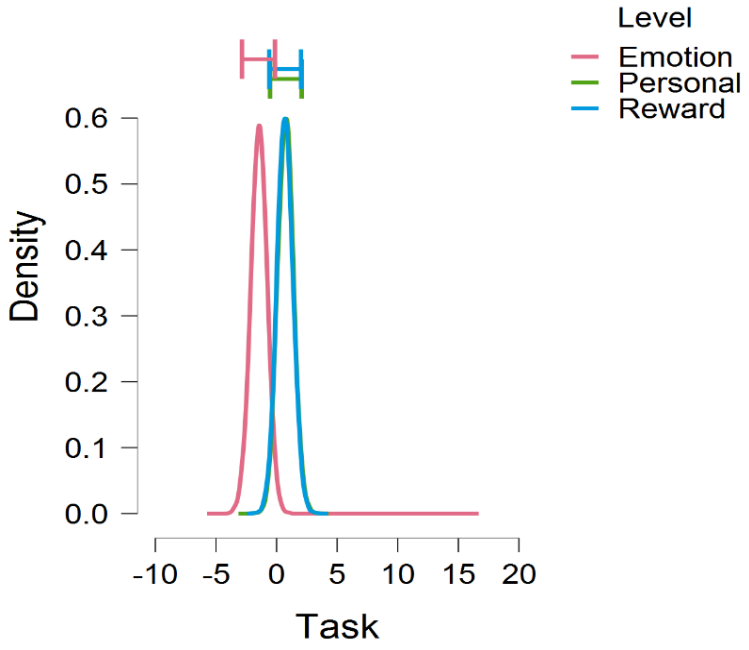

Figure 3a: Average posterior distribution for Task (Personal, Reward and Emotion) for accuracy performance. This figure demonstrates that there is mostly an overlap between posterior distributions for Emotion and Reward Task each of them being compared to posterior distribution for self. i.e. Posterior distributions for personal task was used as a reference. Because there was slight gap between the posterior distributions for the Task Post-Hoc comparison was conducted within the Bayesian framework (for Post-Hoc comparisons between the posterior distribution for Task (Personal, Reward and Emotion) for accuracy performance see Table 1a)

Table 1a

Post-Hoc comparisons for posterior distribution for Task (Personal, Reward and Emotion) for accuracy performance.

		Prior Odds	Posterior Odds	$BF_{10, U}$	error %
Personal	Reward	0.587	0.105	0.179	2.247e -6
	Emotion	0.587	0.640	1.089	0.010
Reward	Emotion	0.587	0.302	0.514	2.223e -7

Note. The posterior odds have been corrected for multiple testing by fixing to 0.5 the prior probability that the null hypothesis holds across all comparisons (Westfall, Johnson, & Utts, 1997). Individual comparisons are based on the default t-test with a Cauchy (0, r = 1/sqrt (2)) prior. The "U" in the Bayes factor denotes that it is uncorrected.

The results from the Post-Hoc comparisons of Personal vs reward, Reward vs Emotion and Personal vs Emotion indicates strong evidence in favour of the null hypothesis and demonstrates that there is no evidence that the differences between personal- reward- and emotion-tasks supports the alternative hypothesis (i.e., that there is a significant main effect of Task).

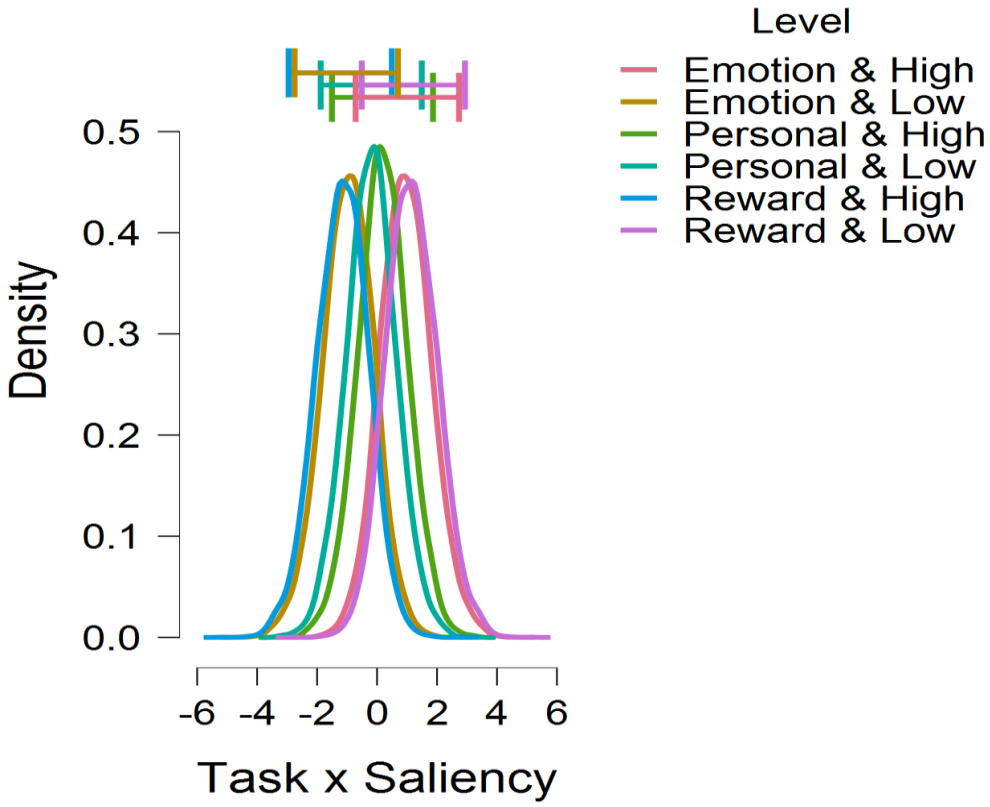

Figure 4a: Average posterior distribution for Task (Personal, Reward and Emotion) and Saliency Level (High and Low) for accuracy performance of matched trials. This figure demonstrates that there is mostly an overlap between posterior distributions for Task and Saliency thus indicating that there is no significant difference in the posterior distribution for the interaction between Task and Saliency.

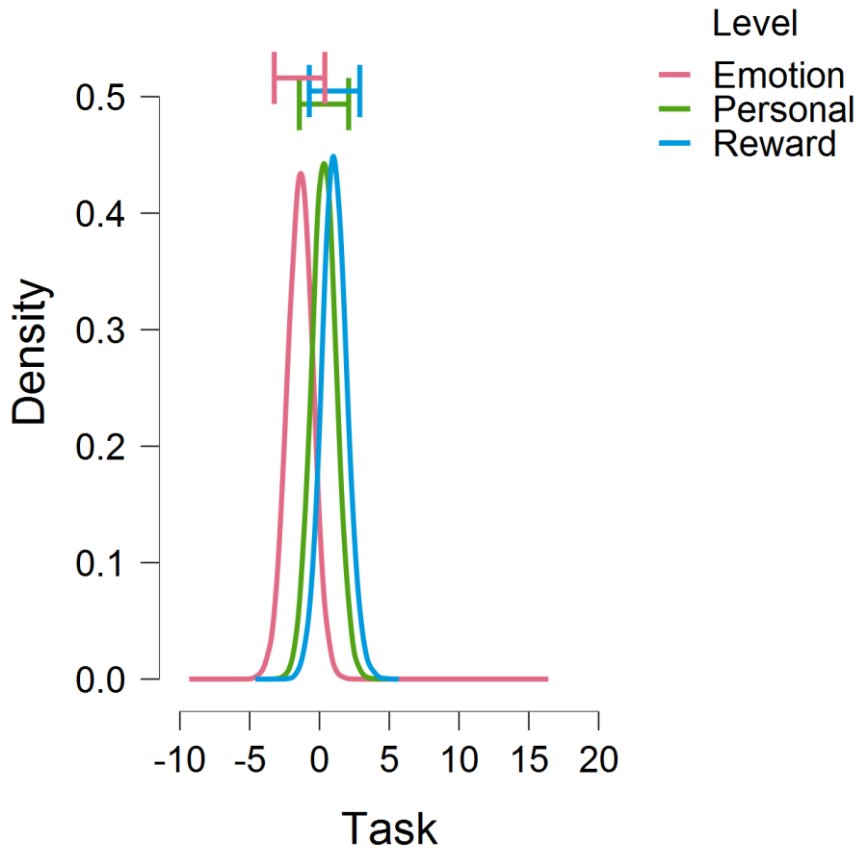

Figure 5a: Average posterior distribution for Task (Personal, Reward and Emotion) for accuracy performance of matched trials. This figure demonstrates that there is an overlap between posterior distributions for Task thus indicating that there is no significant main effect in the posterior distribution for Task.

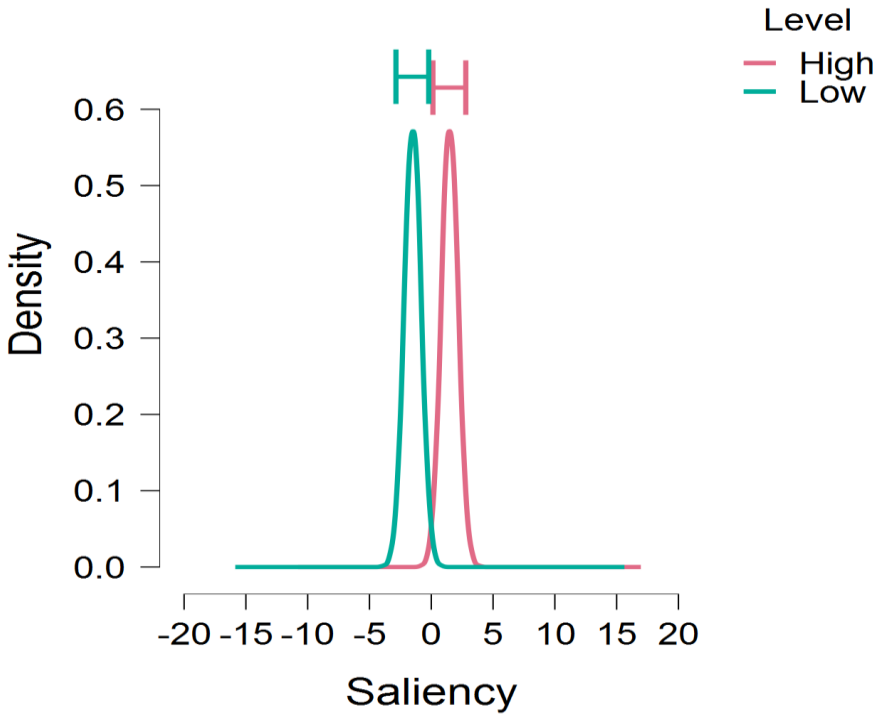

Figure 6a: Average posterior distribution for Saliency (High and Low) for accuracy performance of matched trials. This figure demonstrates that the posterior distribution for Saliency levels are distinct from each other indicating that there is a significant difference in the posterior distribution for Saliency in accuracy performance. Because there was a distinction between the posterior distributions for Saliency, Post-Hoc comparison was conducted within the Bayesian framework (for Post-Hoc comparisons between the posterior distribution for Saliency level for accuracy performance see Table 2a).

Table 2a

Post-Hoc comparisons for posterior distribution for Saliency Level (High and Low) for accuracy performance of matched trials.

	Prior Odds	Posterior Odds	BF_{10}	error %
High Low	1.000	2.311	2.311	4.231e -7

The results from the Post-Hoc comparisons between high vs low saliency indicates posterior odds of 2.31 against the null hypothesis, which demonstrates evidence in favour of the alternative hypothesis (i.e., that high saliency stimuli yield higher accuracy performance compared to low salience stimuli).

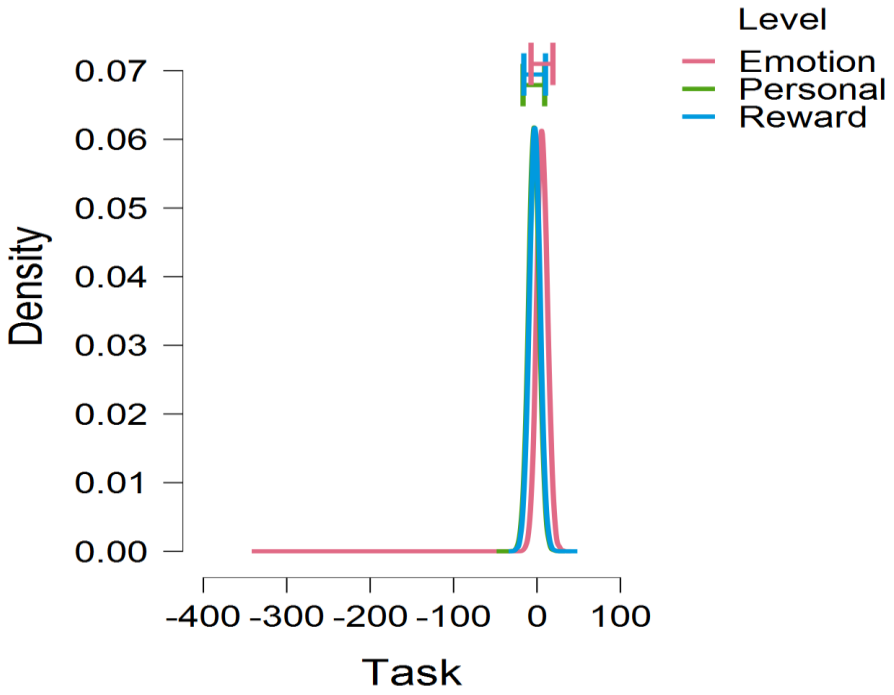

Figure 7a: Average posterior distribution for Task (Personal, Reward and Emotion) for Response Time in all trials (Matched and Mismatched). This figure demonstrates that there is an overlap between posterior distributions for Emotion and Reward Task each of them being compared to posterior distribution for self. i.e. Posterior distributions for personal task was used as a reference.

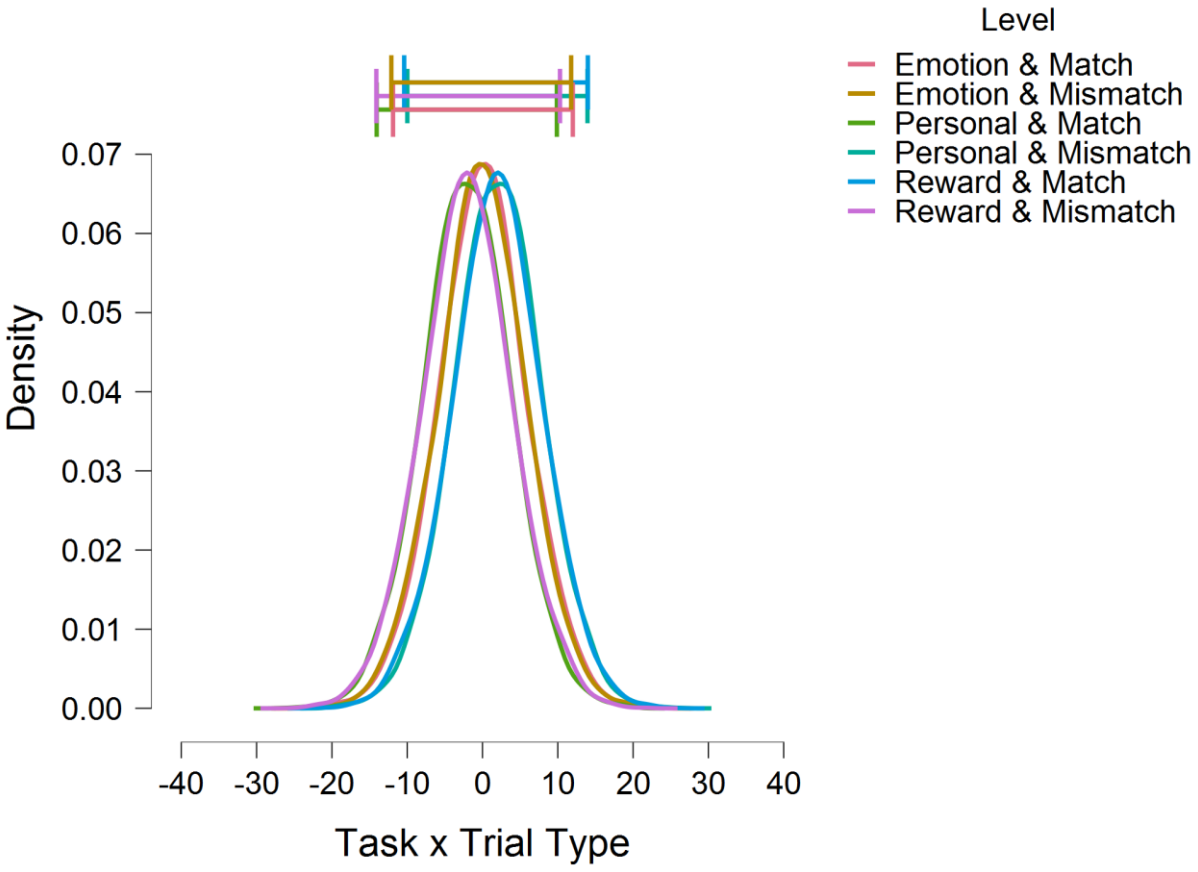

***Figure 8a*:** Average posterior distribution for Task (Personal, Reward and Emotion) and Trial Type (Match and Mismatch) for Response Time. This figure demonstrates that the posterior distribution for Trial Type are almost overlapping each other indicating that there is no significant difference in the posterior distribution for the interaction between Task and Trial Type.

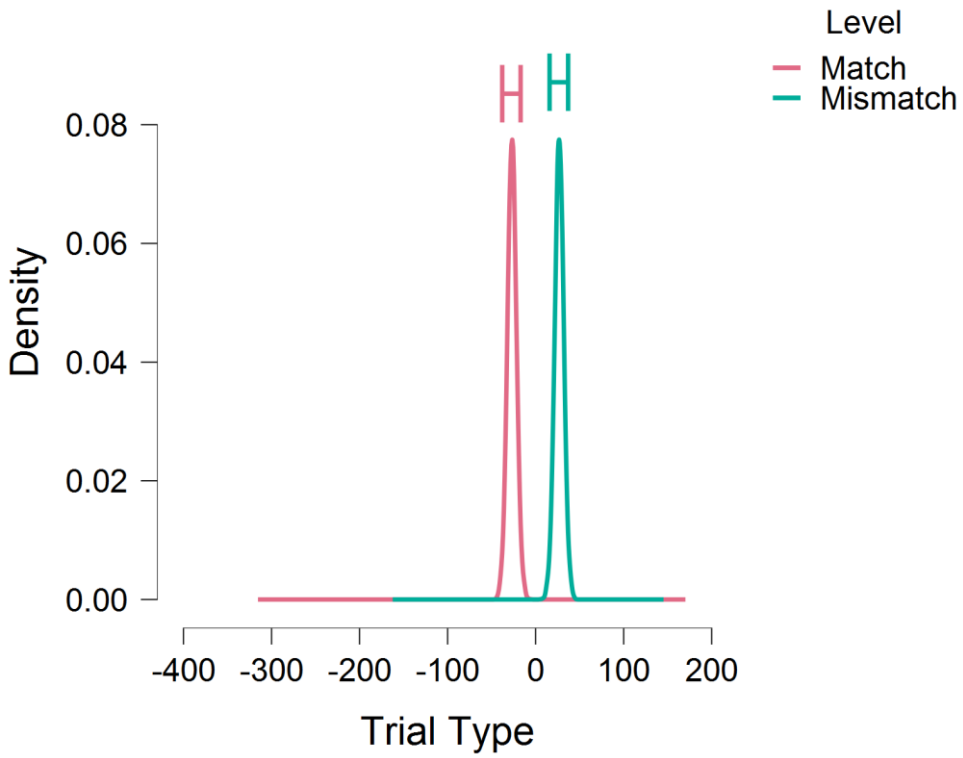

Figure 9a: Average posterior distribution for Trial Type (Match and Mismatch) for Response Time. This figure demonstrates that there is a clear distinction between posterior distributions for Trial Type thus indicating that there is a significant difference in the posterior distribution for Trial Type in Response Time. Because there was a distinction between the posterior distributions for Trial Type, Post-Hoc comparison was conducted within the Bayesian framework (for Post-Hoc comparisons between the posterior distribution for Trial Type for Response Time see Table 3a).

Table 3a

Post-Hoc comparisons for posterior distribution for Trial Type (Match and Mismatch) for Response Time.

		Prior Odds	Posterior Odds	$BF_{10, U}$	error %
Match	Mismatch	1.000	3.040e +20	3.040e +20	4.009e -24

Note. The posterior odds have been corrected for multiple testing by fixing to 0.5 the prior probability that the null hypothesis holds across all comparisons (Westfall, Johnson, & Utts, 1997). Individual comparisons are based on the default t-test with a Cauchy (0, r = 1/sqrt(2)) prior. The "U" in the Bayes factor denotes that it is uncorrected.

The results from the Post-Hoc comparisons between Match and Mismatch trials indicates posterior odds of 3.04 against the null hypothesis, which demonstrates evidence in favour of the alternative hypothesis (i.e., that Match yield lower Response Time compared to Mismatched stimuli)

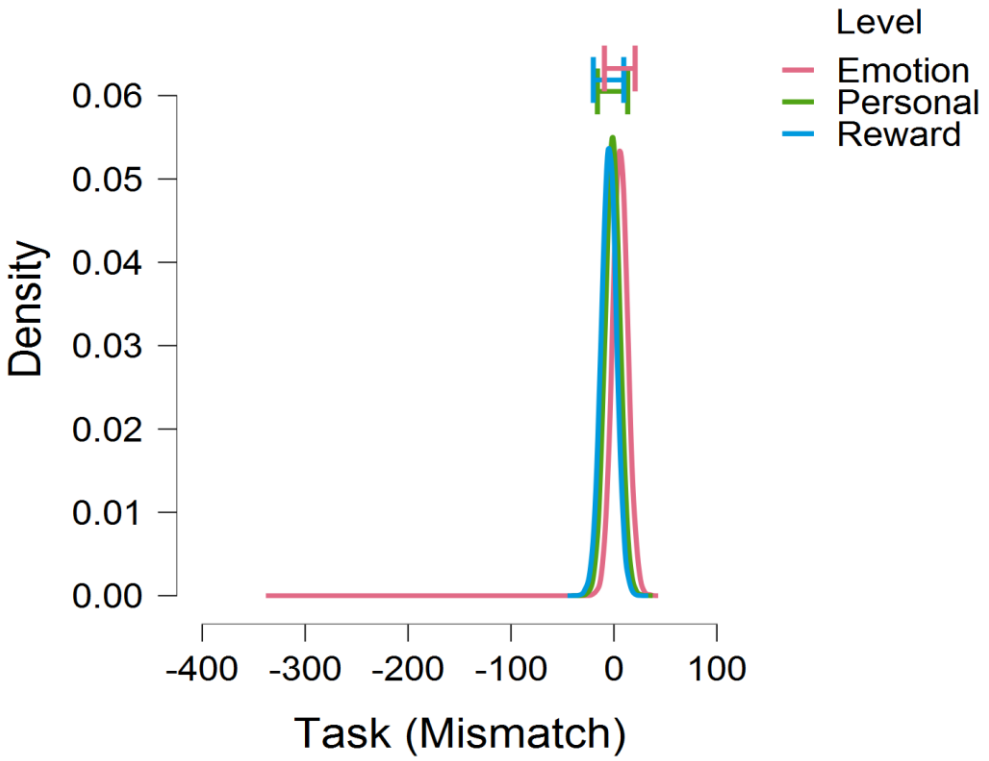

Figure 10a: Average posterior distribution for Task (Personal, Reward and Emotion; Mismatched trials) for Response Time. This figure demonstrates that there is an overlap between posterior distributions for Emotion and Reward Task each of them being compared to posterior distribution for self. i.e. Posterior distributions for personal task was used as a reference.

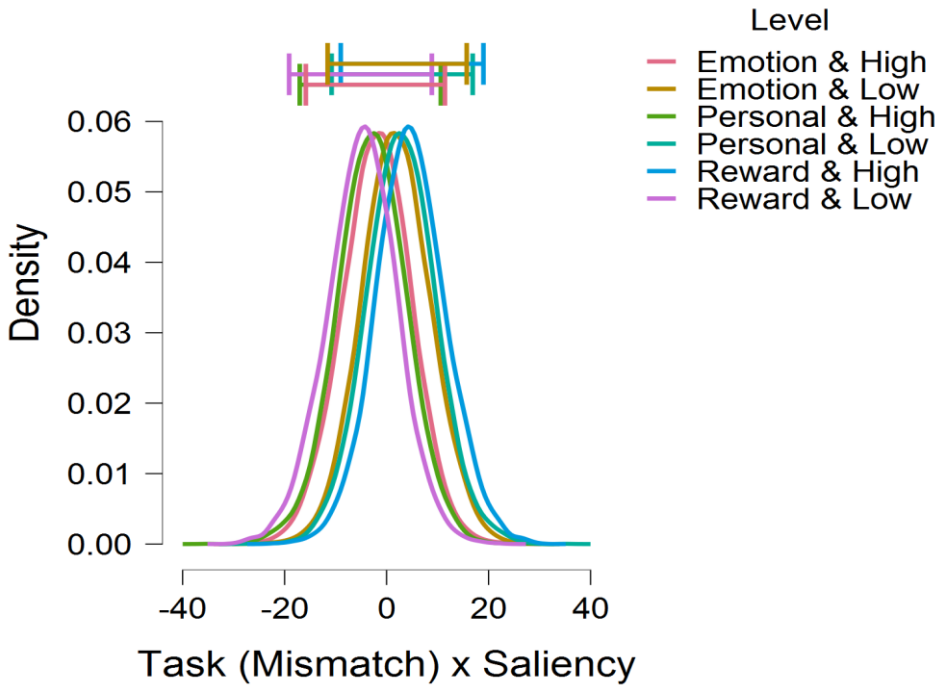

***Figure 11a*:** Average posterior distribution for Task (Personal, Reward and Emotion; Mismatched Trials) and Saliency (High/Low) for Response Time. This figure demonstrates that the posterior distribution for Task are almost overlapping each other indicating that there is no significant difference in the posterior distribution for the interaction between Task and Saliency.

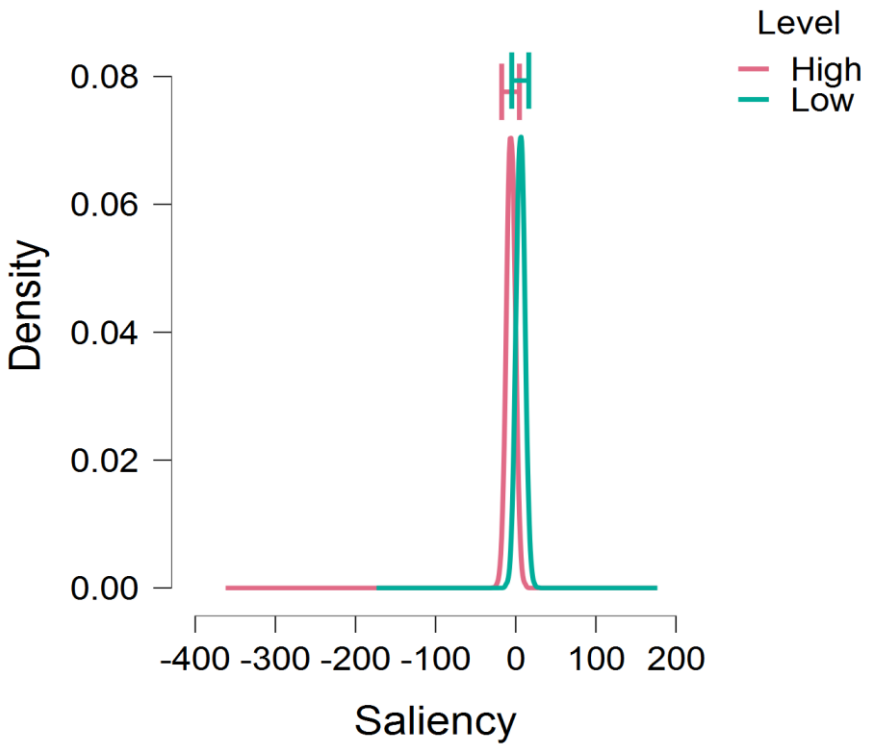

Figure 12a: Average posterior distribution for Saliency (High/Low) for Response Time of Mismatched Trials. This figure demonstrates that there is an overlap between posterior distributions for Saliency thus indicating that there is no significant difference in the posterior distribution for the Saliency.

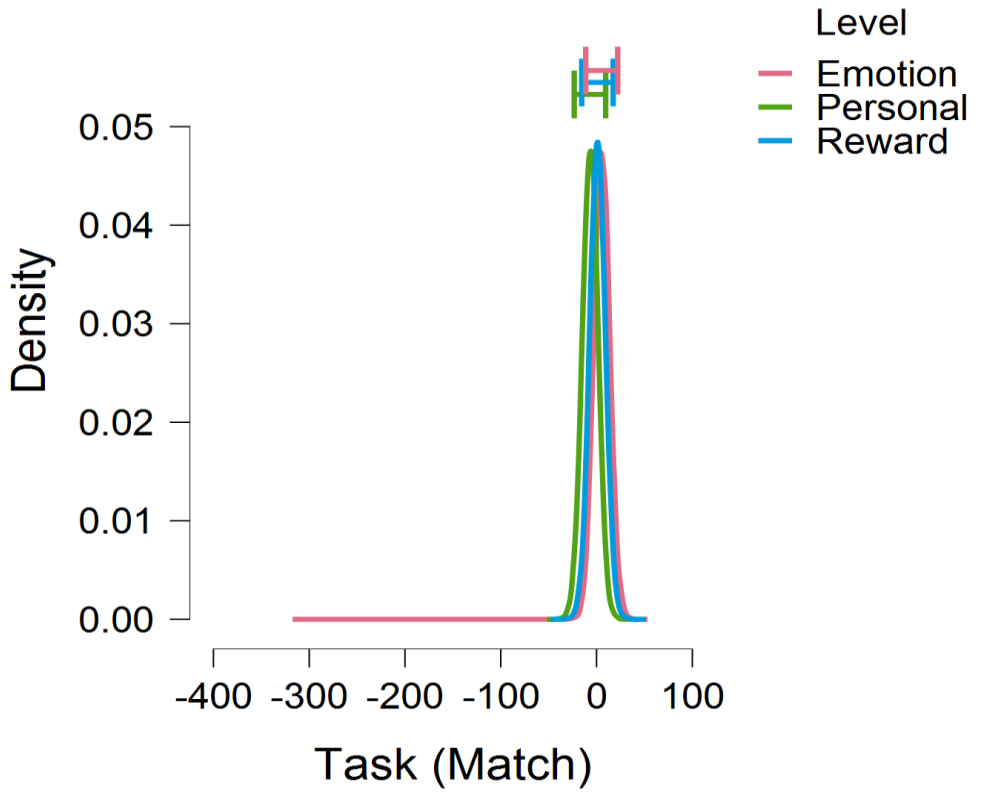

Figure 13a: Average posterior distribution for Task (Personal, Reward and Emotion; Matched trials) for Response Time. This figure demonstrates that there is an overlap between posterior distributions for Reward and Emotion task, each of them being compared to posterior distribution for self. i.e. Posterior distributions for personal task was used as a reference, thus indicating that there is no significant difference in the posterior distribution for the Task.

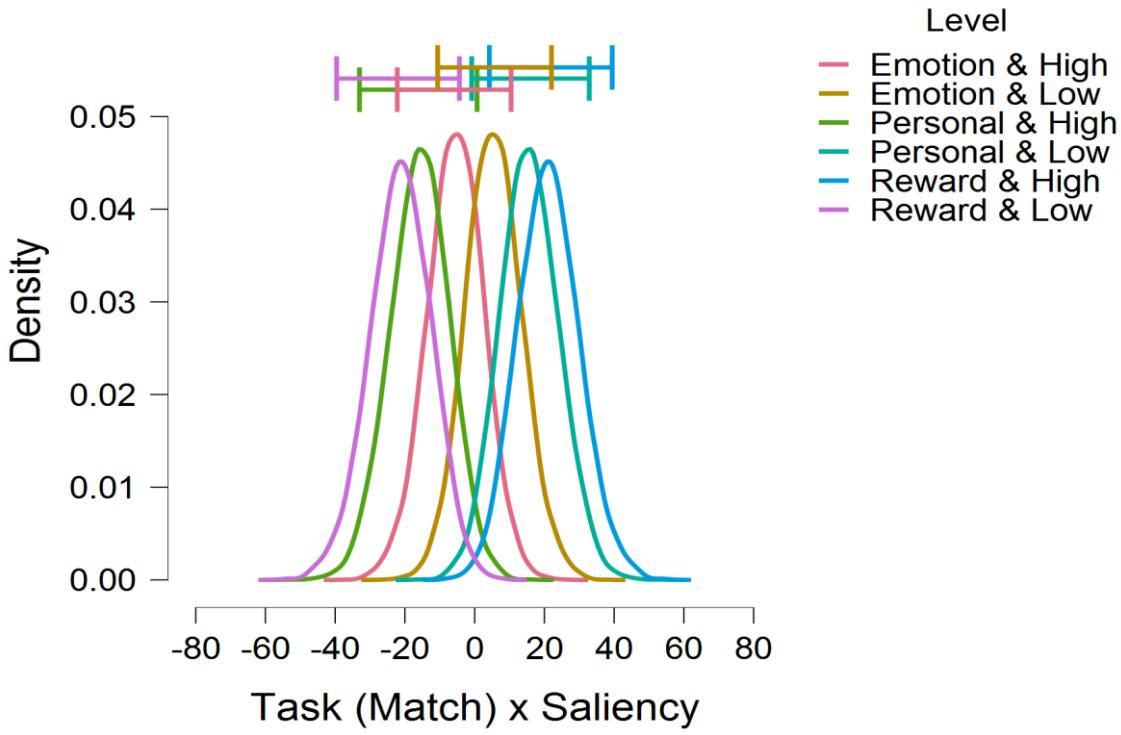

***Figure 14a*:** Average posterior distribution for Task (Personal, Reward and Emotion; Matched Trials) and Saliency (High/Low) for Response Time. This figure demonstrates that the posterior distribution for Task are distinct from each other indicating that there is a significant difference in the posterior distribution for the interaction between Task and Saliency.

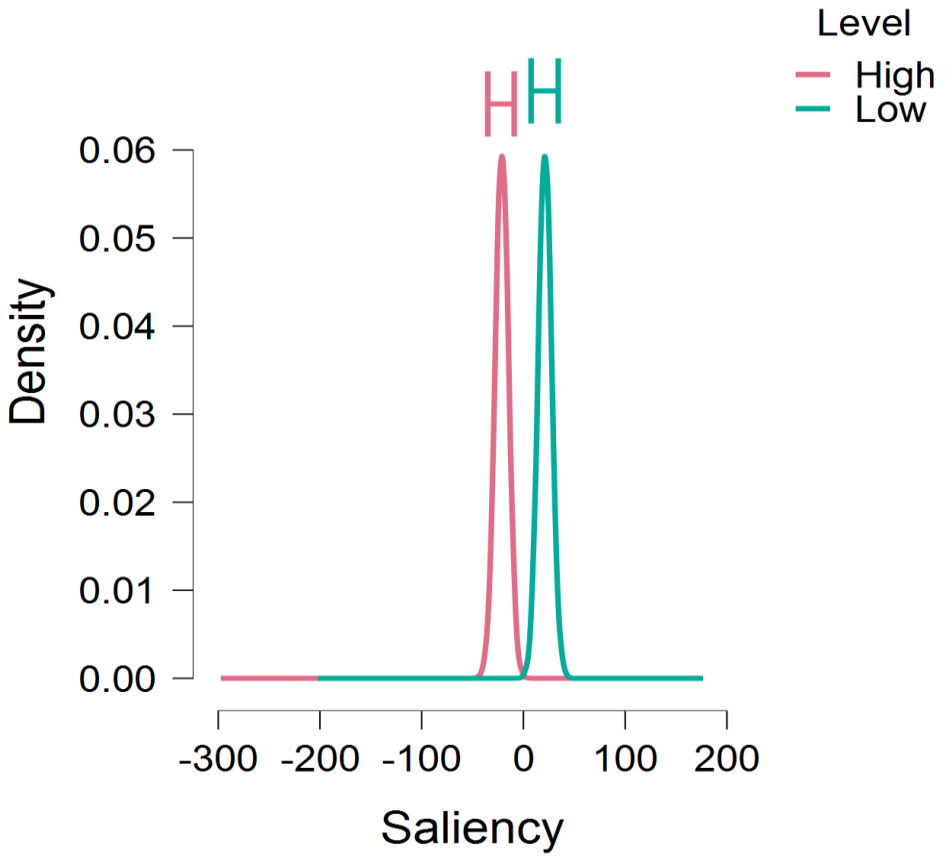

Figure 15a: Average posterior distribution for Saliency (High and Low) for Response Time of Matched Trials. This figure demonstrates that there is a clear distinction between posterior distributions for Saliency thus indicating that there is a significant difference in the posterior distribution for Saliency in Response Time of Matched Trials. Because there was a distinction between the posterior distributions for Saliency, Post-Hoc comparison was conducted within the Bayesian framework (for Post-Hoc comparisons between the posterior distribution for Saliency for Response Time see Table 4a).

Table 4a

Post-Hoc comparisons for posterior distribution for Saliency Level (High and Low) for Response Time of matched trials.

		Prior Odds	Posterior Odds	$BF_{10, U}$	error %
High	Low	1.000	51.548	51.548	8.911e -8

Note. The posterior odds have been corrected for multiple testing by fixing to 0.5 the prior probability that the null hypothesis holds across all comparisons (Westfall, Johnson, & Utts, 1997). Individual comparisons are based on the default t-test with a Cauchy (0, r = 1/sqrt (2)) prior. The "U" in the Bayes factor denotes that it is uncorrected.

The results from the Post-Hoc comparisons between High vs Low saliency indicates posterior odds of 51.55 against the null hypothesis, which demonstrates decisive evidence in favour of the alternative hypothesis (i.e., that high saliency stimuli yield Lower Response Time compared to low salience stimuli).

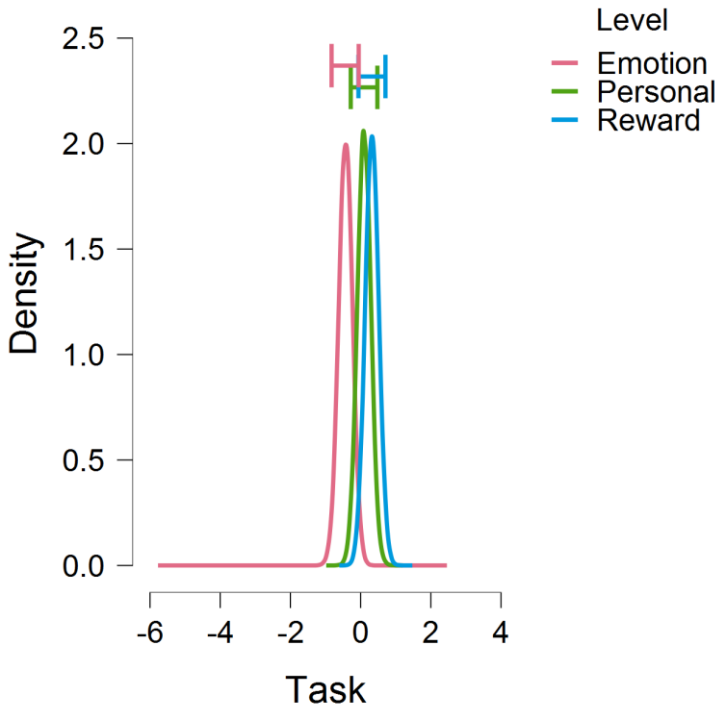

Figure 16a: Average posterior distribution for Task (Personal, Reward and Emotion) for mean amplitude of P1. This figure demonstrates that there mostly and overlap between posterior distributions for Task thus indicating that there is no significant difference in the posterior distribution for Task for mean amplitude of P1.

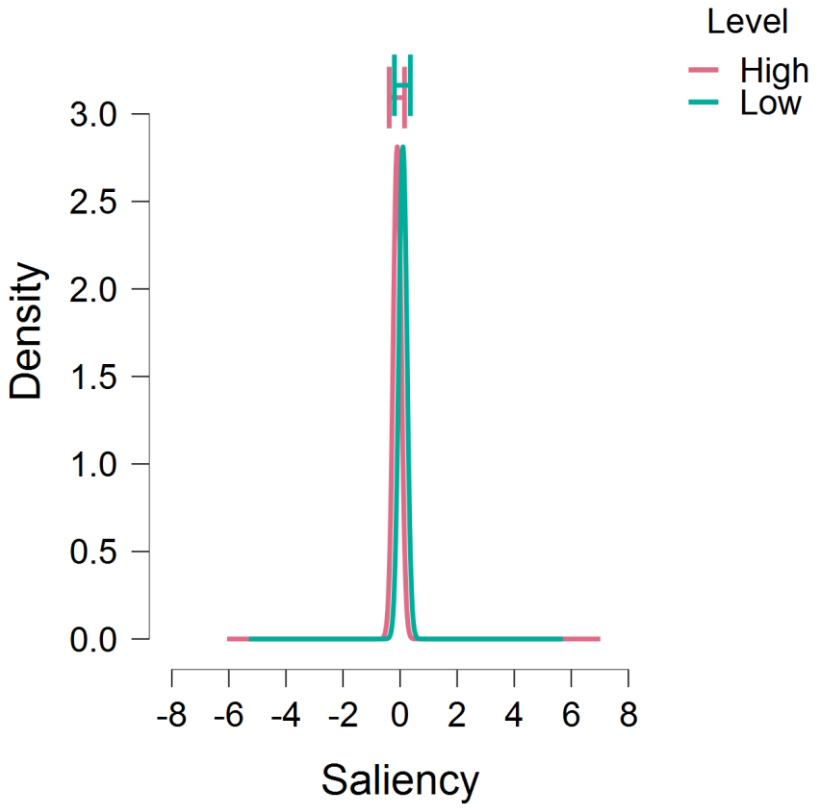

Figure 17a: Average posterior distribution for Saliency (High/Low) for mean amplitude of P1. This figure demonstrates that there is a clear overlap between posterior distributions for Saliency thus indicating that there is no significant difference in the posterior distribution for Saliency for mean amplitude of P1.

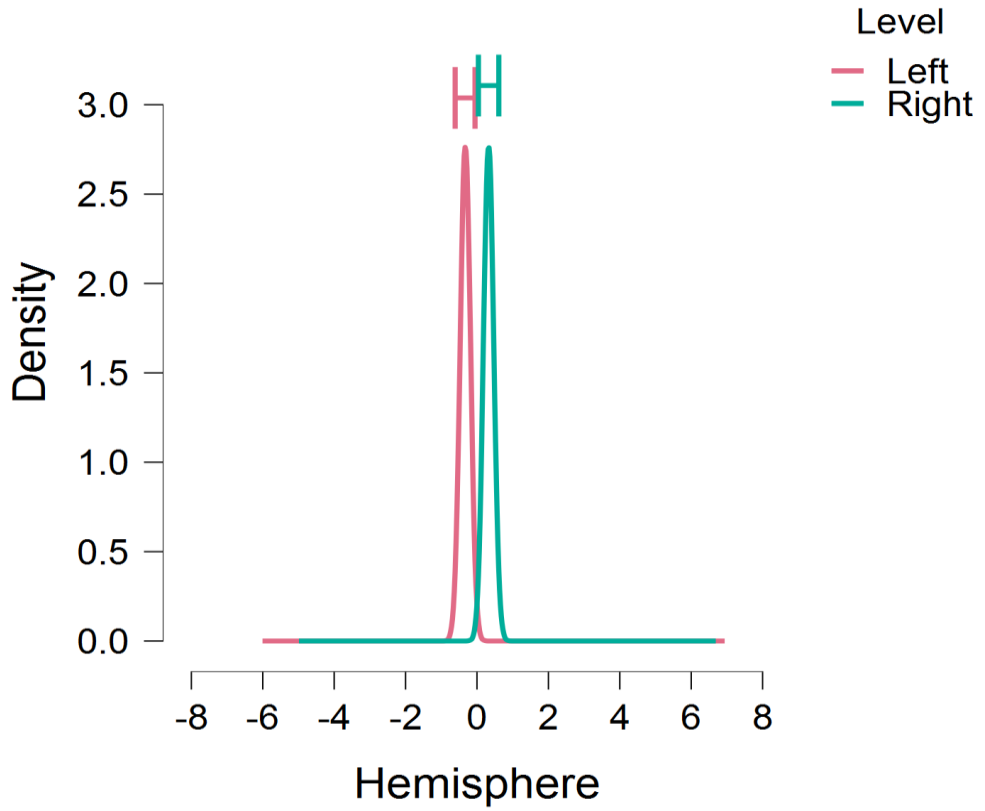

Figure 18a: Average posterior distribution for Hemisphere (Left/Right) for mean amplitude of P1. This figure demonstrates that there is a slight distinction between posterior distributions for Hemisphere thus indicating that there is significant difference in the posterior distribution for Hemisphere for mean amplitude of P1. Because there was a distinction between the posterior distributions for Hemisphere, Post-Hoc comparison was conducted within the Bayesian framework (for Post-Hoc comparisons between the posterior distribution for Hemisphere for mean amplitude of P1 see Table 5a).

Table 5a

Post-Hoc comparisons for posterior distribution for Hemisphere (Left/Right) for mean amplitude of P1.

		Prior Odds	Posterior Odds	$BF_{10, U}$	error %
Left	Right	1.000	13.799	13.799	3.641e -7

Note. The posterior odds have been corrected for multiple testing byfixing to 0.5 the prior probability that the null hypothesis holds across all comparisons (Westfall, Johnson, & Utts, 1997). Individual comparisons are based on the default t-test with a Cauchy (0, r = 1/sqrt(2)) prior. The "U" in the Bayes factor denotes that it is uncorrected.

The results from the Post-Hoc comparisons between Left vs Right Hemisphere indicates posterior odds of 13.8 against the null hypothesis, which demonstrates evidence in favour of the alternative hypothesis (i.e., that there is a difference in mean amplitude of P1 between the right and left hemisphere).

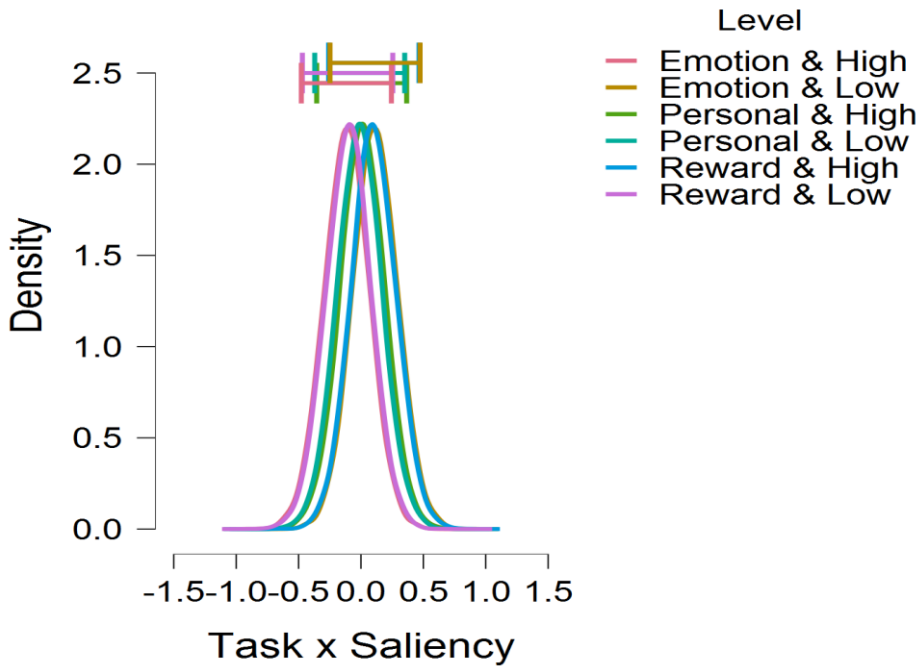

Figure 19a: Average posterior distribution for Task (Personal, Reward and Emotion) and Saliency Level (High and Low) for mean amplitude of P1. This figure demonstrates that there is an overlap between posterior distributions for Task and Saliency thus indicating that there is no significant difference in the posterior distribution for the interaction between Task and Saliency.

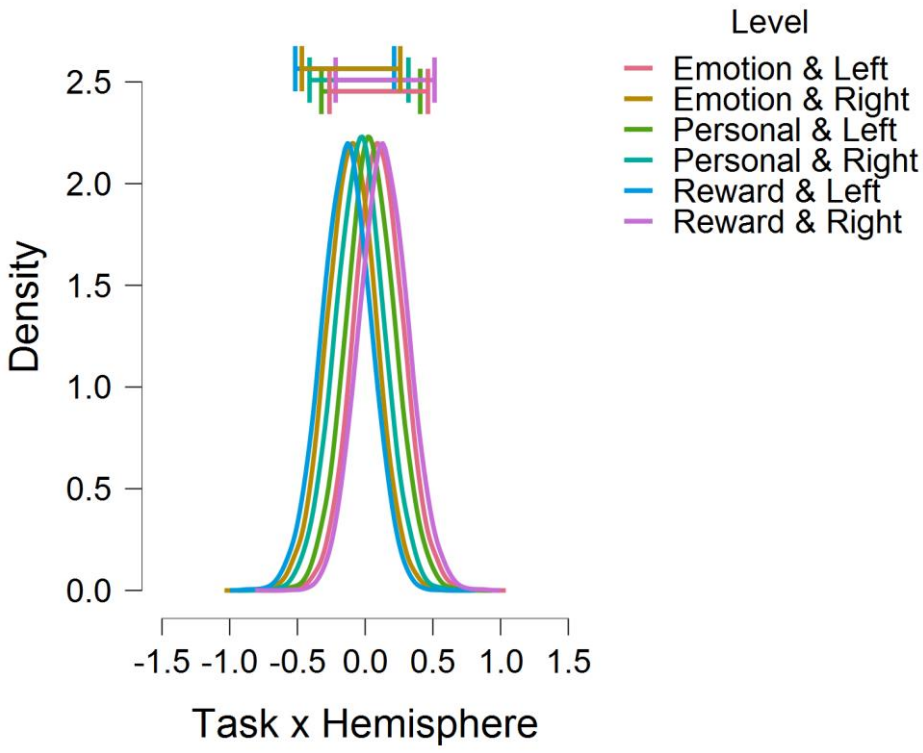

Figure 20a: Average posterior distribution for Task (Personal, Reward and Emotion) and Hemisphere (Left/Right) for mean amplitude of P1. This figure demonstrates that there is an overlap between posterior distributions for Task and Hemisphere thus indicating that there is no significant difference in the posterior distribution for the interaction between Task and Hemisphere.

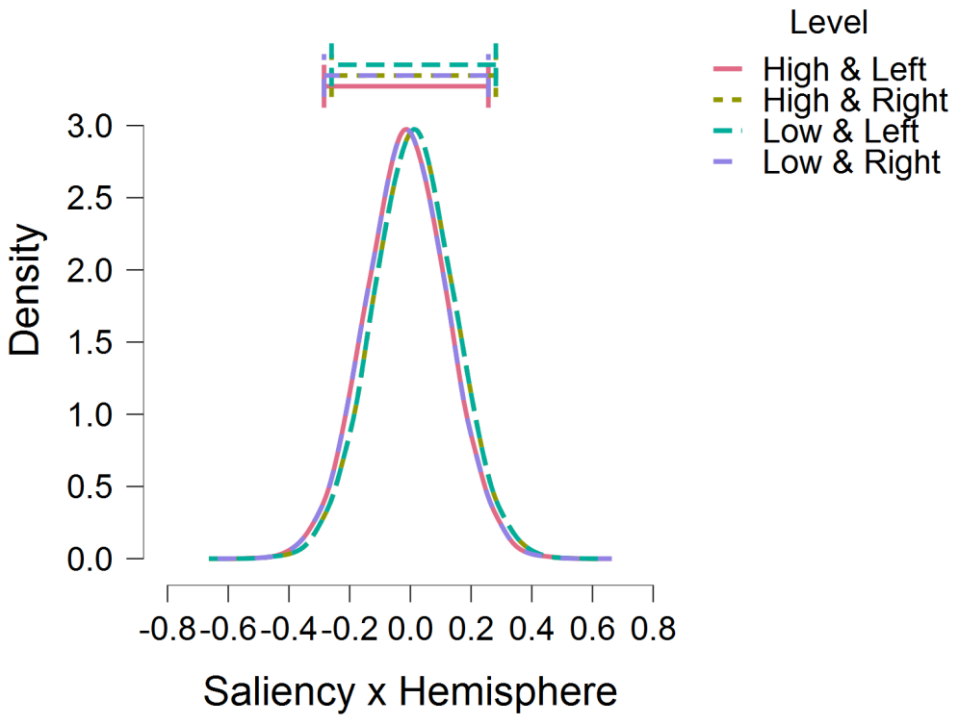

Figure 21a: Average posterior distribution for Saliency (High/Low) and Hemisphere (Left/Right) for mean amplitude of P1. This figure demonstrates that there is an overlap between posterior distributions for Saliency and Hemisphere thus indicating that there is no significant difference in the posterior distribution for the interaction between Saliency and Hemisphere.

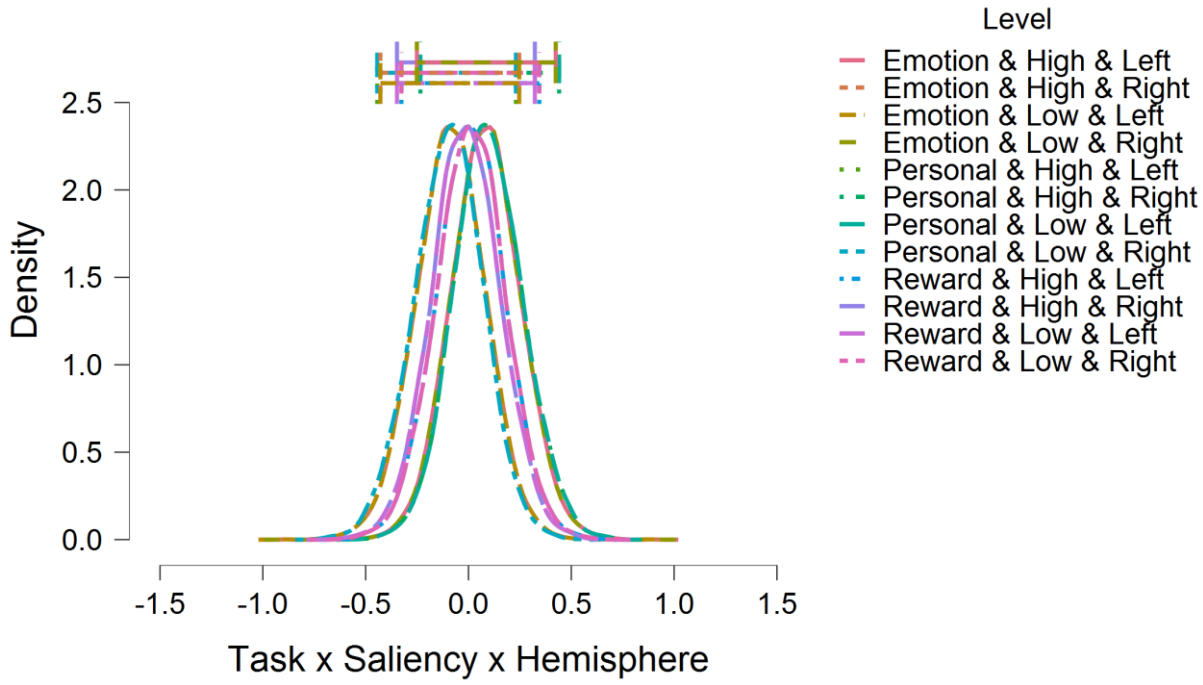

Figure 22a: Average posterior distribution for Task (Personal, Reward, Emotion), Saliency (High/Low) and Hemisphere (Left/Right) for mean amplitude of P1. This figure demonstrates that there is an overlap between posterior distributions for Task, Saliency and Hemisphere thus indicating that there is no significant difference in the posterior distribution for the interaction between Task, Saliency and Hemisphere.

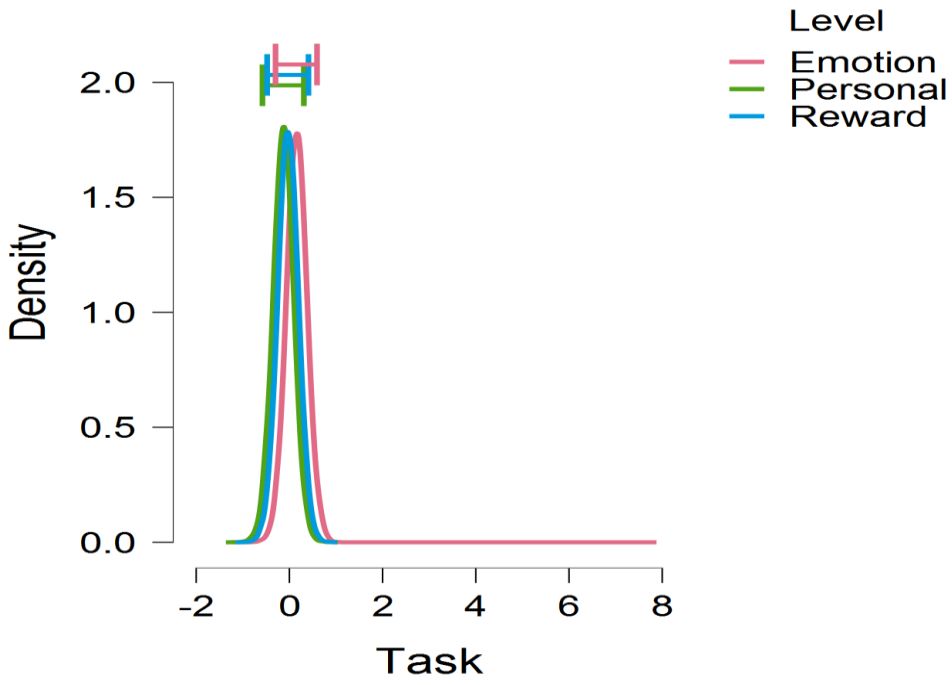

Figure 23a: Average posterior distribution for Task (self, reward, emotion) for mean amplitude of anterior N1. This figure demonstrates that there is an overlap between posterior distributions for Task thus indicating that there is no significant difference in the posterior distribution for the Task for the mean amplitude of anterior N1.

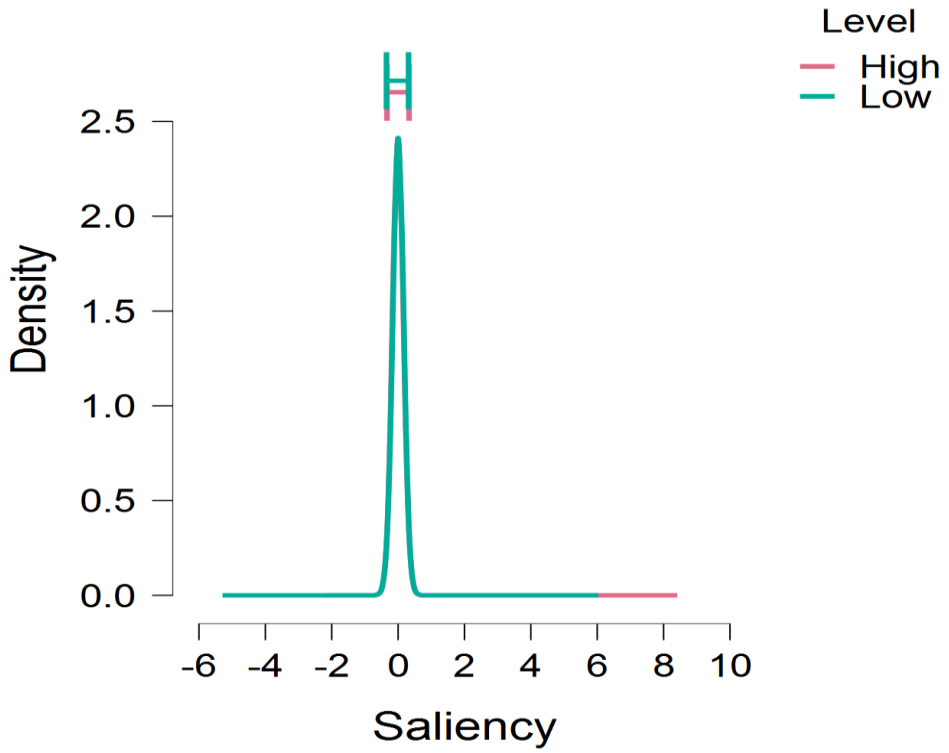

Figure 24a: Average posterior distribution for Saliency (High/Low) for mean amplitude of anterior N1. This figure demonstrates that there is an overlap between posterior distributions for Saliency thus indicating that there is no significant difference in the posterior distribution for the Saliency for the mean amplitude of anterior N1.

***Figure 25a*:** Average posterior distribution for Task (Personal, Reward and Emotion) and Saliency (High/Low) for mean amplitude of anterior N1. This figure demonstrates that the posterior distribution for Task are distinct from each other indicating that there is a significant difference in the posterior distribution for the interaction between Task and Saliency.

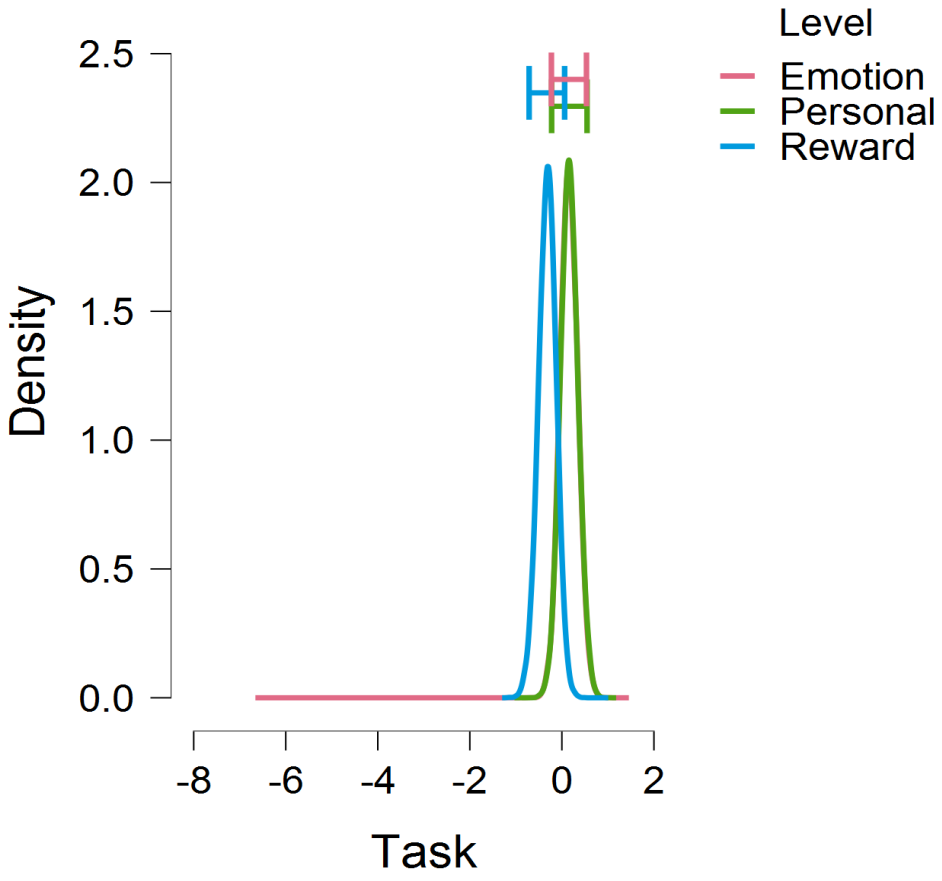

Figure 26a: Average posterior distribution for Task (Personal, Reward and Emotion) for mean amplitude of posterior N1. This figure demonstrates that there mostly and overlap between posterior distributions for Task thus indicating that there is no significant difference in the posterior distribution for Task for mean amplitude of posterior N1.

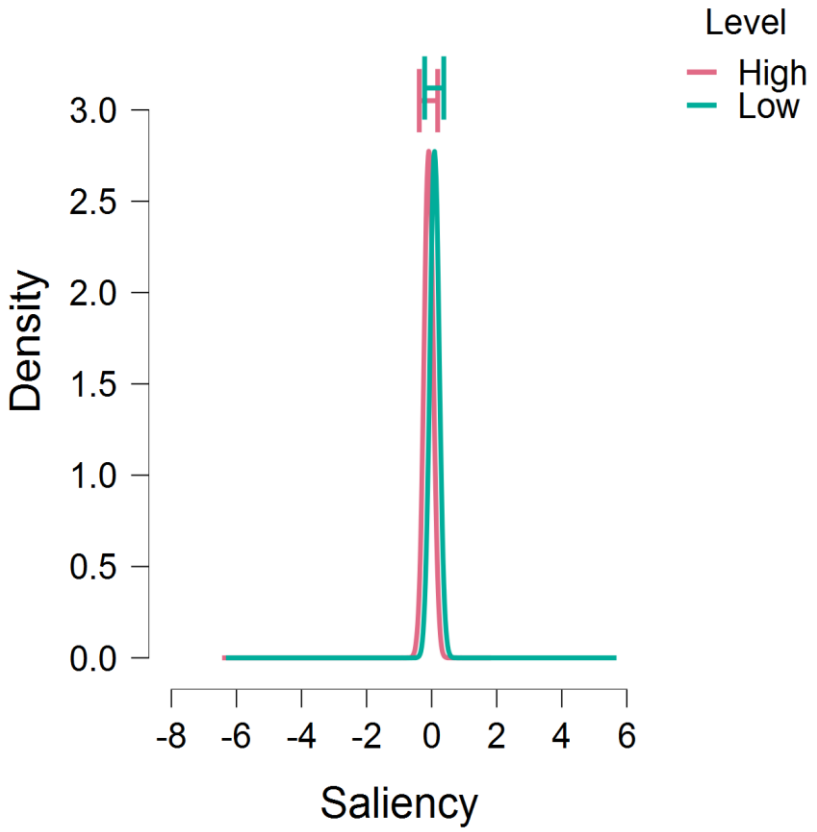

Figure 27a: Average posterior distribution for Saliency (High/Low) for mean amplitude of posterior N1. This figure demonstrates that there is an overlap between posterior distributions for Saliency thus indicating that there is no significant difference in the posterior distribution for the Saliency for the mean amplitude of posterior N1.

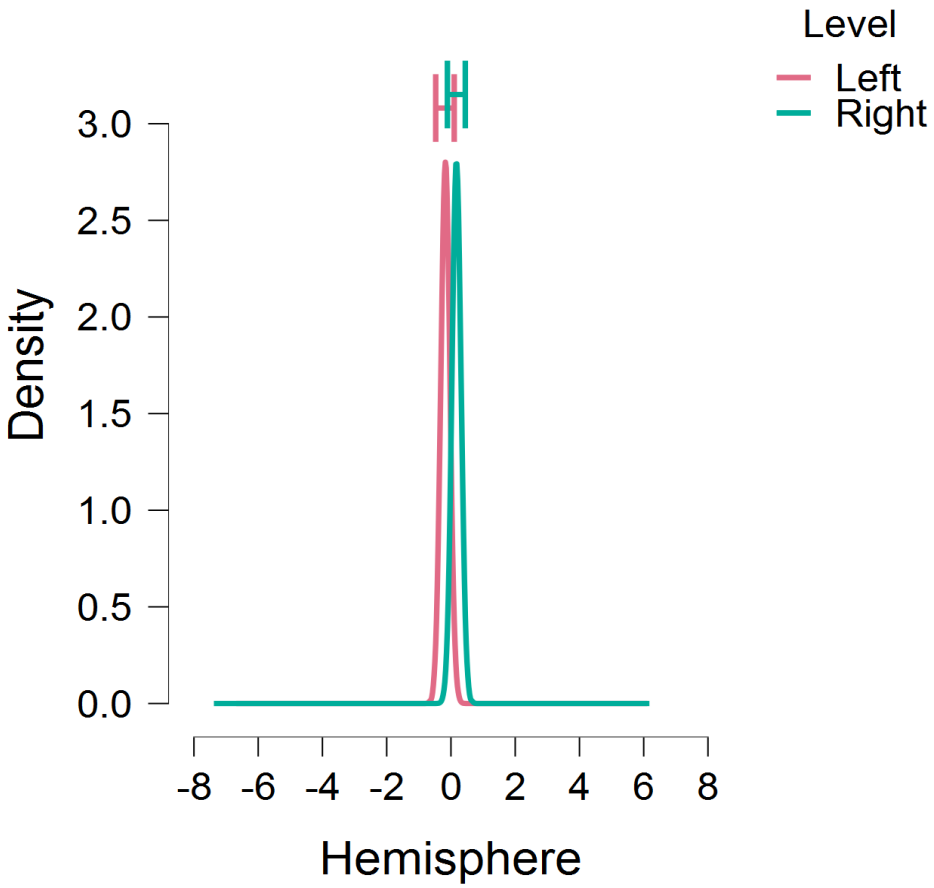

Figure 28a: Average posterior distribution for Hemisphere (Left/Right) for mean amplitude of posterior N1. This figure demonstrates that there is an overlap between posterior distributions for Hemisphere thus indicating that there is no significant difference in the posterior distribution for Hemisphere for the mean amplitude of posterior N1.

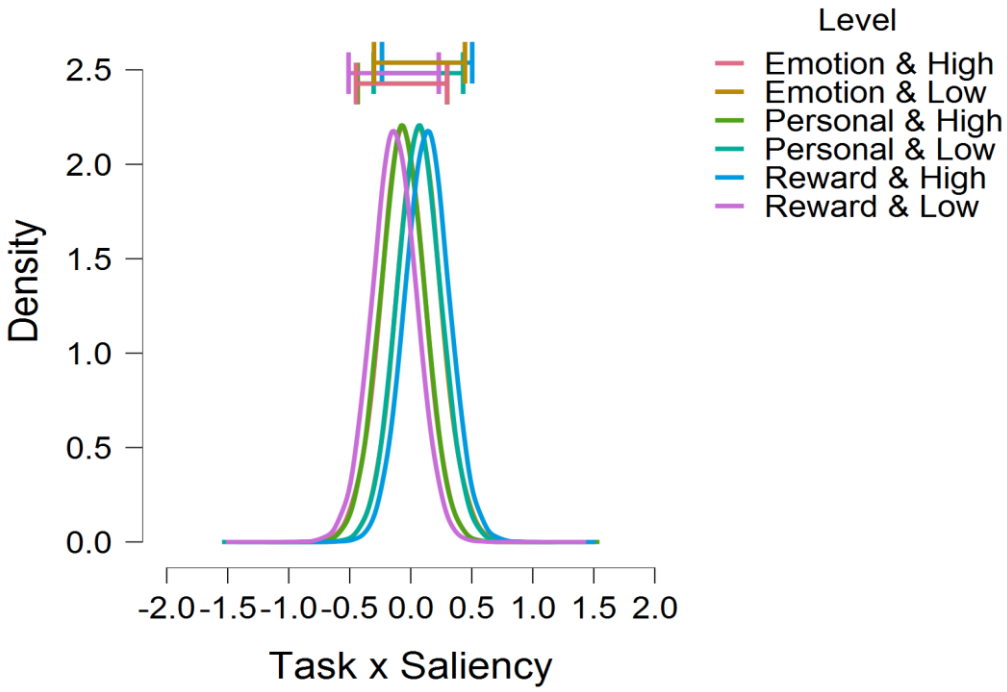

Figure 29a: Average posterior distribution for Task (Personal, Reward and Emotion) and Saliency Level (High and Low) for mean amplitude of posterior N1. This figure demonstrates that there is an overlap between posterior distributions for Task and Saliency thus indicating that there is no significant difference in the posterior distribution for the interaction between Task and Saliency.

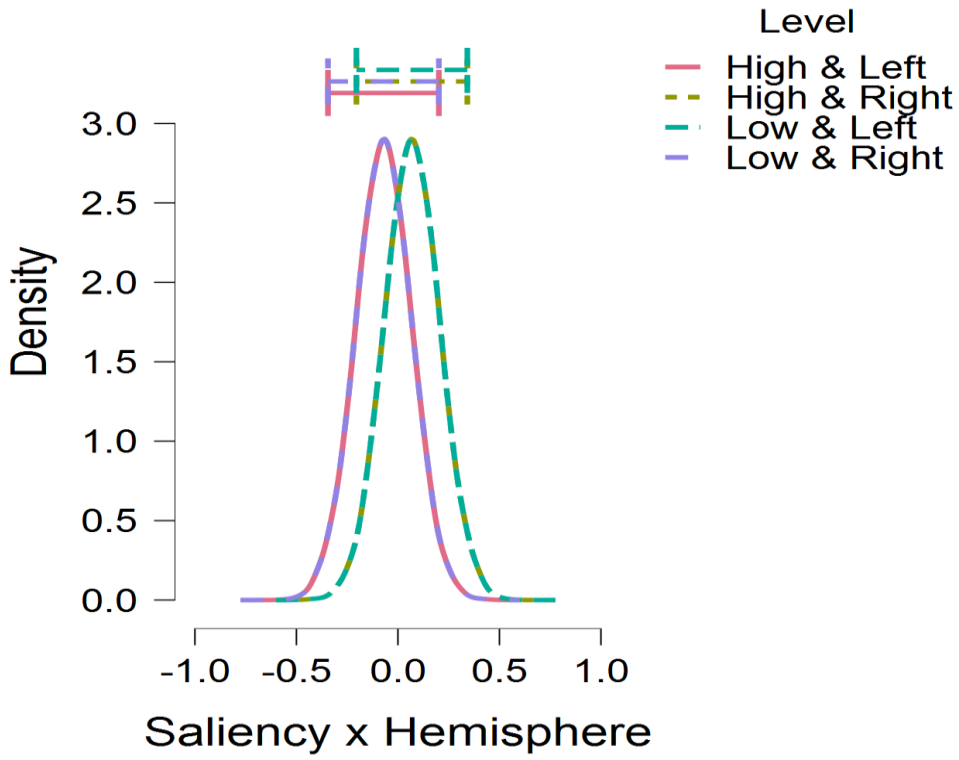

Figure 30a: Average posterior distribution for Saliency (High/Low) and Hemisphere (Left/Right) for mean amplitude of posterior N1. This figure demonstrates that there is mostly an overlap between posterior distributions for Saliency and Hemisphere thus indicating that there is no significant difference in the posterior distribution for the interaction between Saliency and Hemisphere.

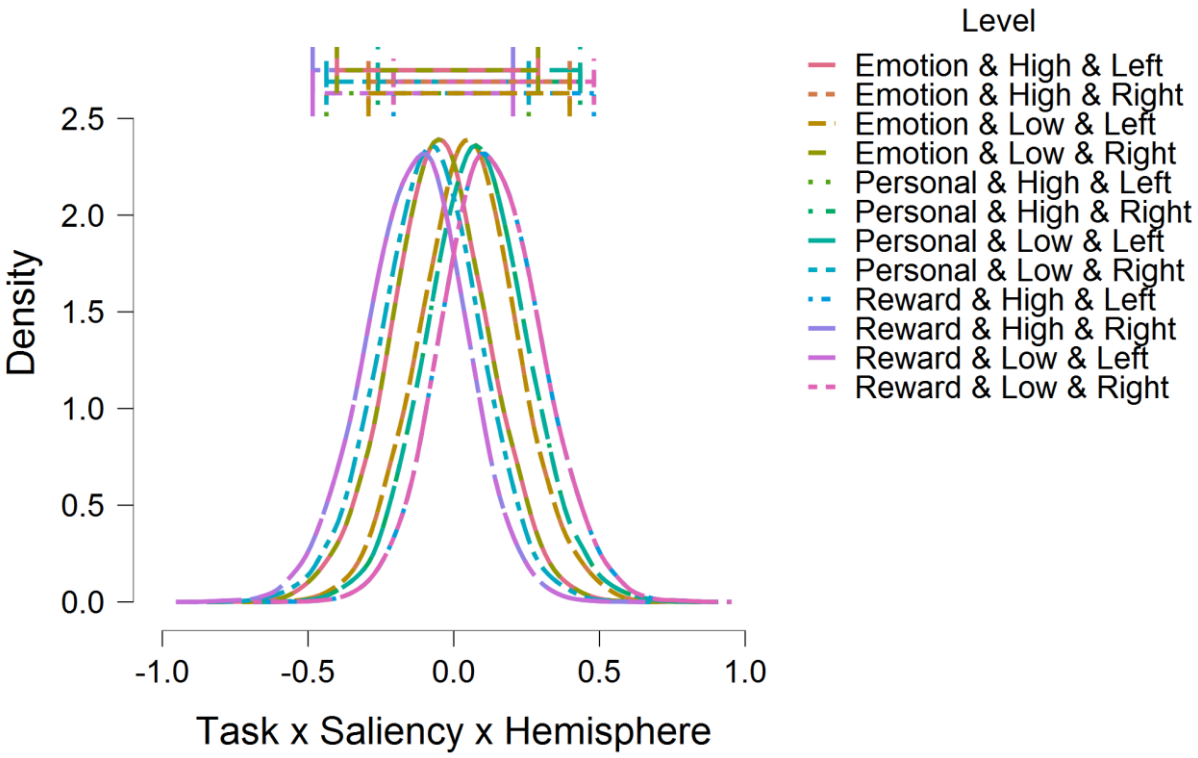

Figure 31a: Average posterior distribution for Task (Personal, Reward, Emotion), Saliency (High/Low) and Hemisphere (Left/Right) for mean amplitude of posterior N1. This figure demonstrates that there is an overlap between posterior distributions for Task, Saliency and Hemisphere thus indicating that there is no significant difference in the posterior distribution for the interaction between Task, Saliency and Hemisphere.

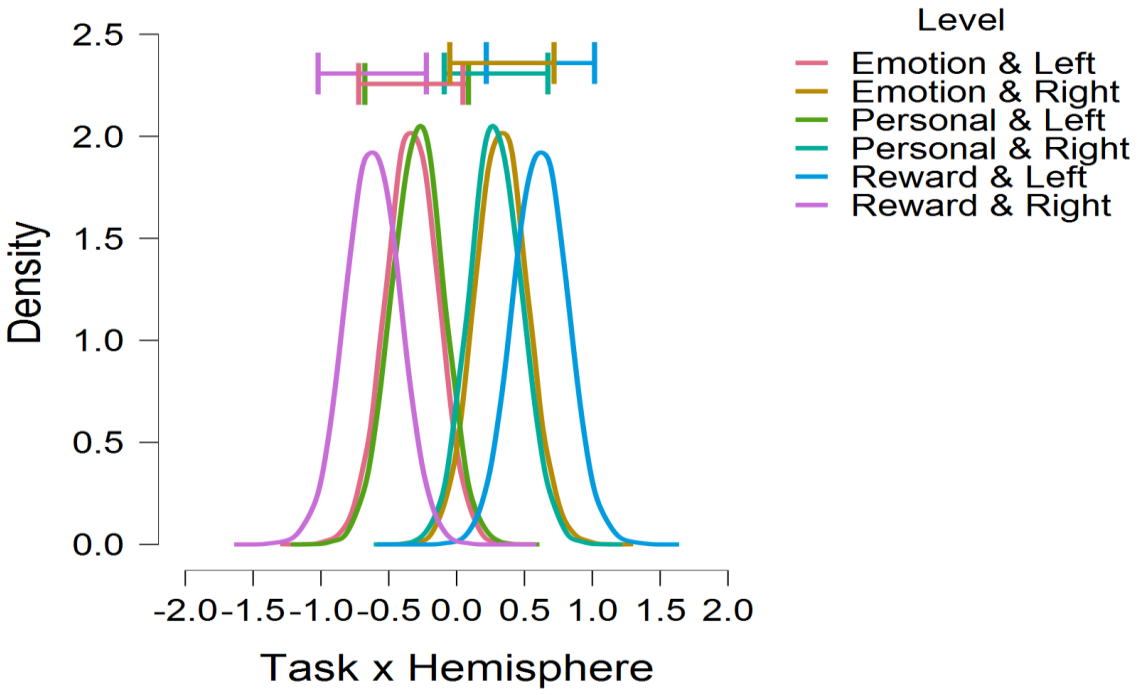

Figure 32a: Average posterior distribution for Task (Personal, Reward and Emotion) and Hemisphere (Left/Right) for mean amplitude of posterior N1. This figure demonstrates that there is a clear distinction between posterior distributions for Task and Hemisphere thus indicating that there is a significant difference in the posterior distribution for the interaction between Task and Hemisphere.

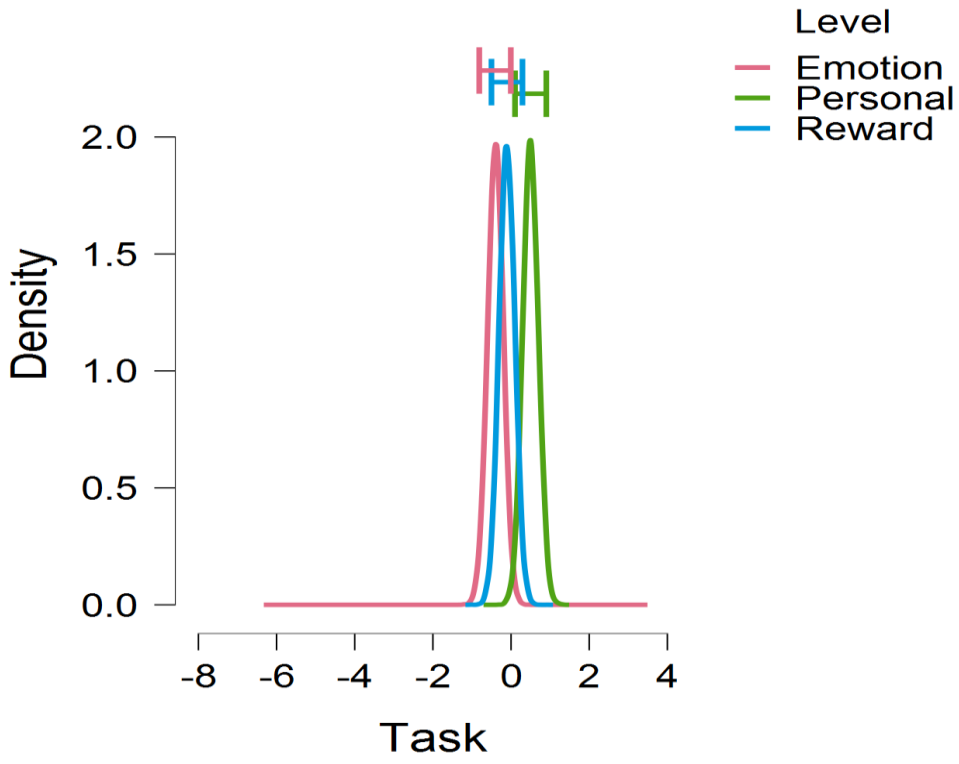

Figure 33a: Average posterior distribution for Task (Personal, Reward and Emotion) for mean amplitude of anterior P2. This figure demonstrates that there mostly and overlap between posterior distributions for Task thus indicating that there is no significant difference in the posterior distribution for Task for mean amplitude of anterior P2.

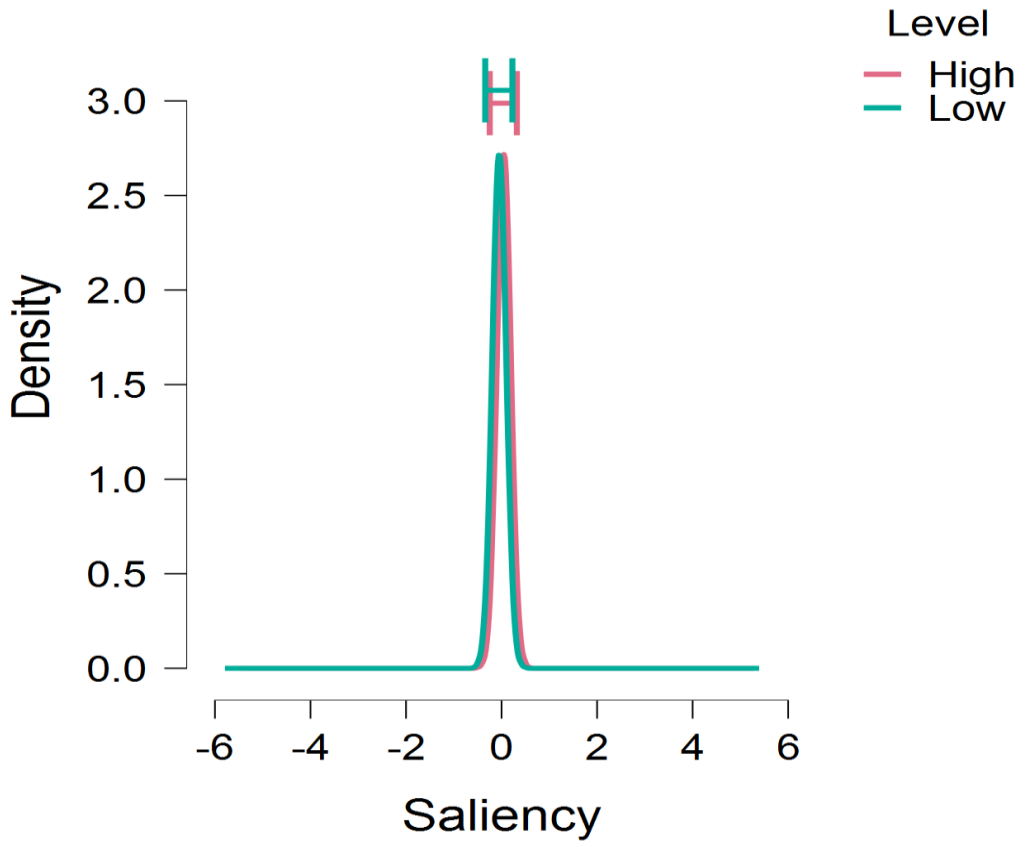

Figure 34a: Average posterior distribution for Saliency (High/Low) for mean amplitude of anterior P2. This figure demonstrates that there is an overlap between posterior distributions for Saliency thus indicating that there is no significant difference in the posterior distribution for Saliency for mean amplitude of anterior P2.

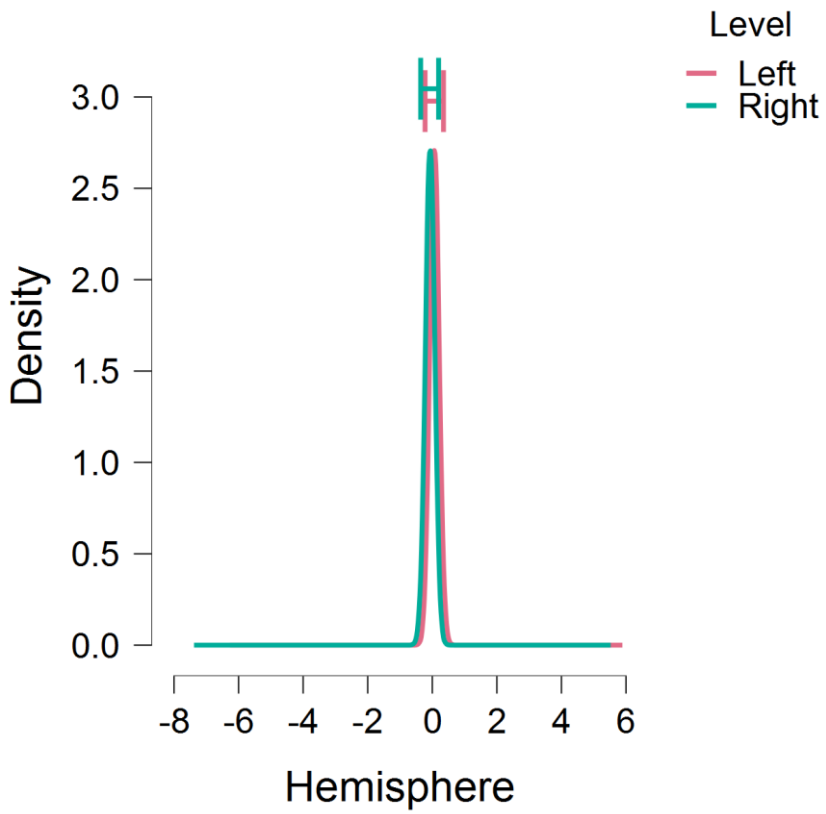

Figure 35a: Average posterior distribution for Hemisphere (Left/Right) for mean amplitude of anterior P2. This figure demonstrates that there is an overlap between posterior distributions for Hemisphere thus indicating that there is no significant difference in the posterior distribution for Hemisphere for mean amplitude of anterior P2.

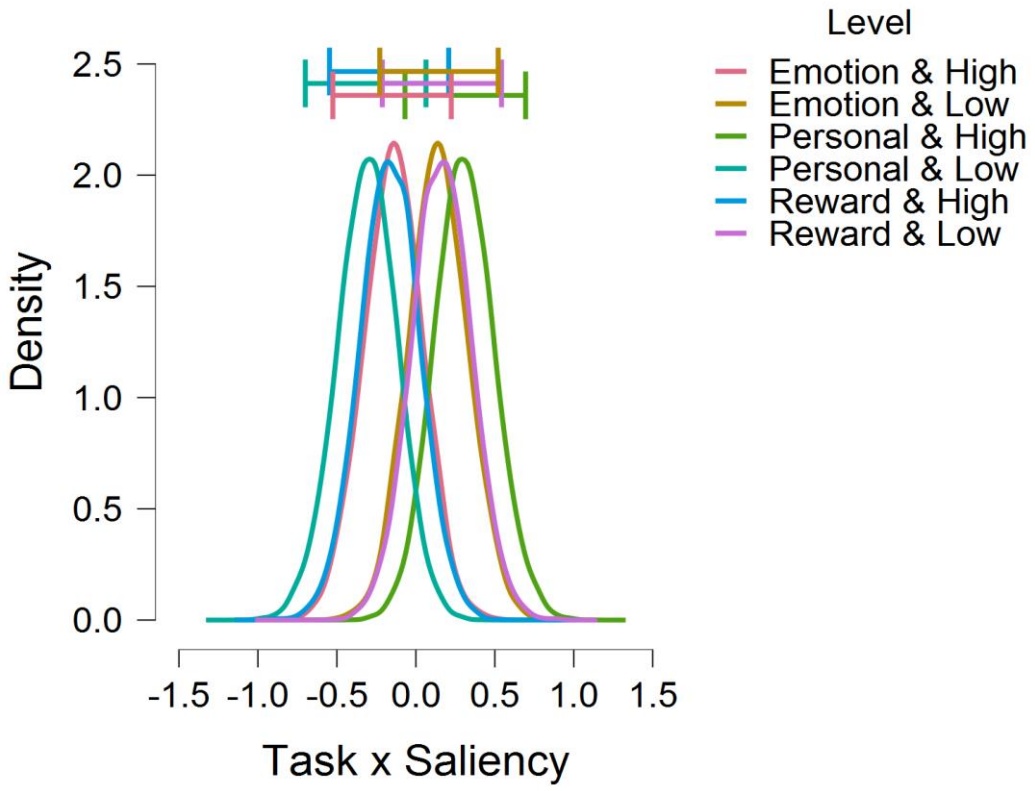

Figure 36a: Average posterior distribution for Task (Personal, Reward and Emotion) and Saliency Level (High and Low) for mean amplitude of anterior P2. This figure demonstrates that there is mostly an overlap between posterior distributions for Task and Saliency thus indicating that there is no significant difference in the posterior distribution for the interaction between Task and Saliency.

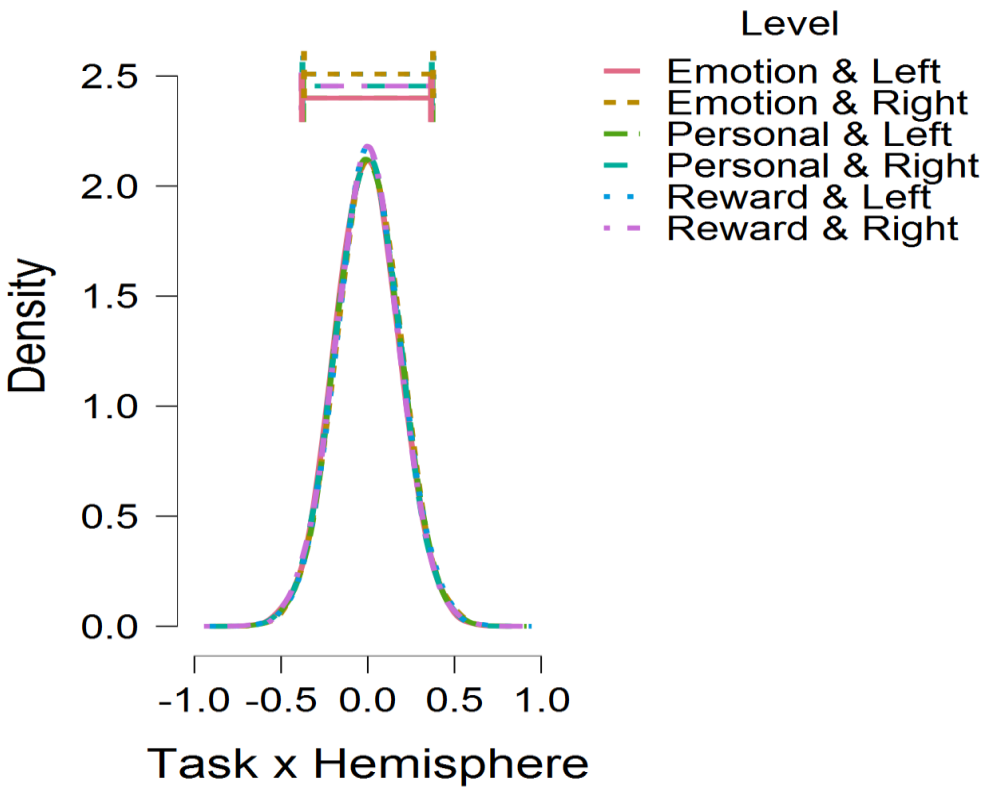

Figure 37a: Average posterior distribution for Task (Personal, Reward and Emotion) and Hemisphere (Left/Right) for mean amplitude of anterior P2. This figure demonstrates that there is an overlap between posterior distributions for Task and Hemisphere thus indicating that there is no significant difference in the posterior distribution for the interaction between Task and Hemisphere.

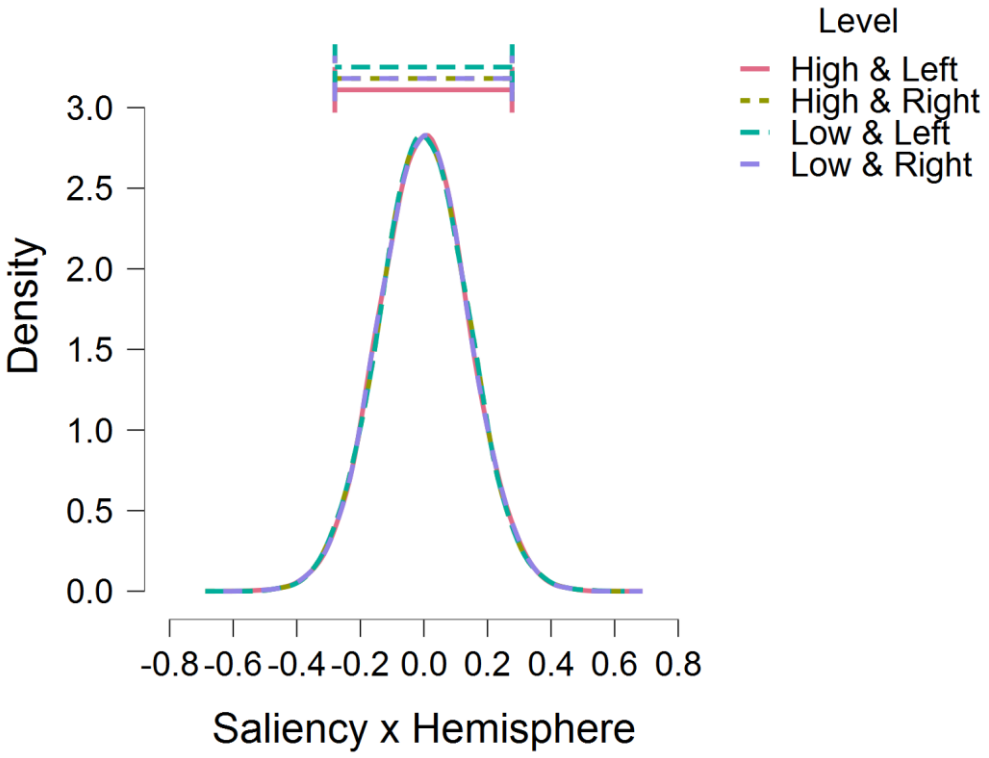

Figure 38a: Average posterior distribution for Saliency (High and Low) and Hemisphere (Left/Right) for mean amplitude of anterior P2. This figure demonstrates that there is an overlap between posterior distributions for Saliency and Hemisphere thus indicating that there is no significant difference in the posterior distribution for the interaction between Saliency and Hemisphere.

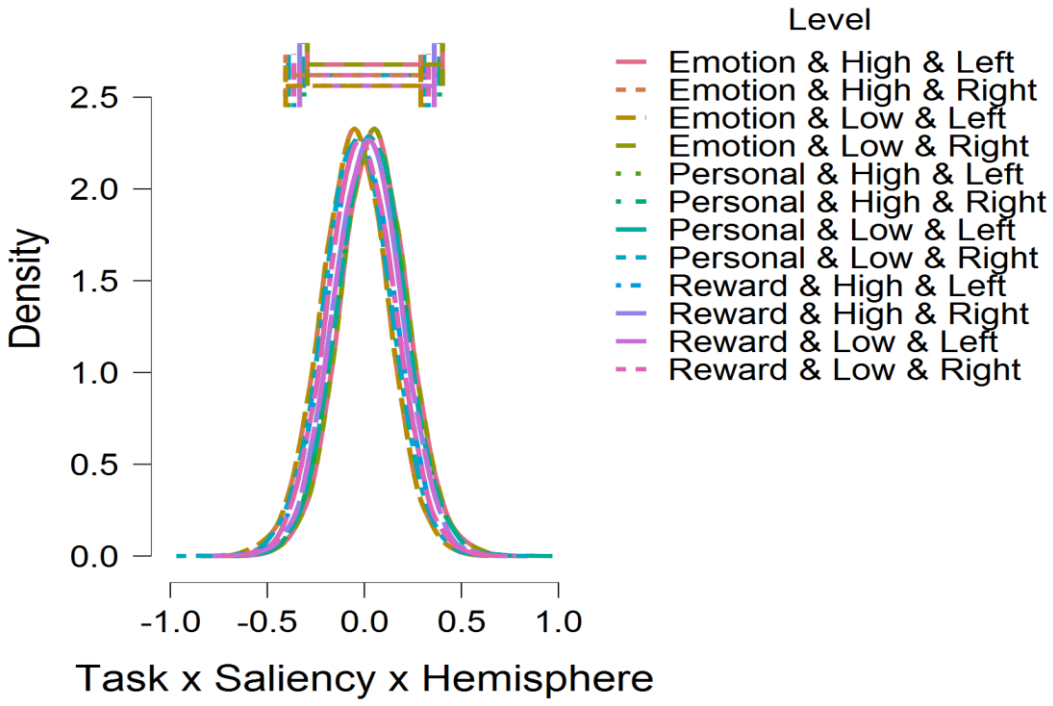

Figure 39a: Average posterior distribution for Task (Personal, Reward, Emotion), Saliency (High/Low) and Hemisphere (Left/Right) for mean amplitude of anterior P2. This figure demonstrates that there is an overlap between posterior distributions for Task, Saliency and Hemisphere thus indicating that there is no significant difference in the posterior distribution for the interaction between Task, Saliency and Hemisphere.

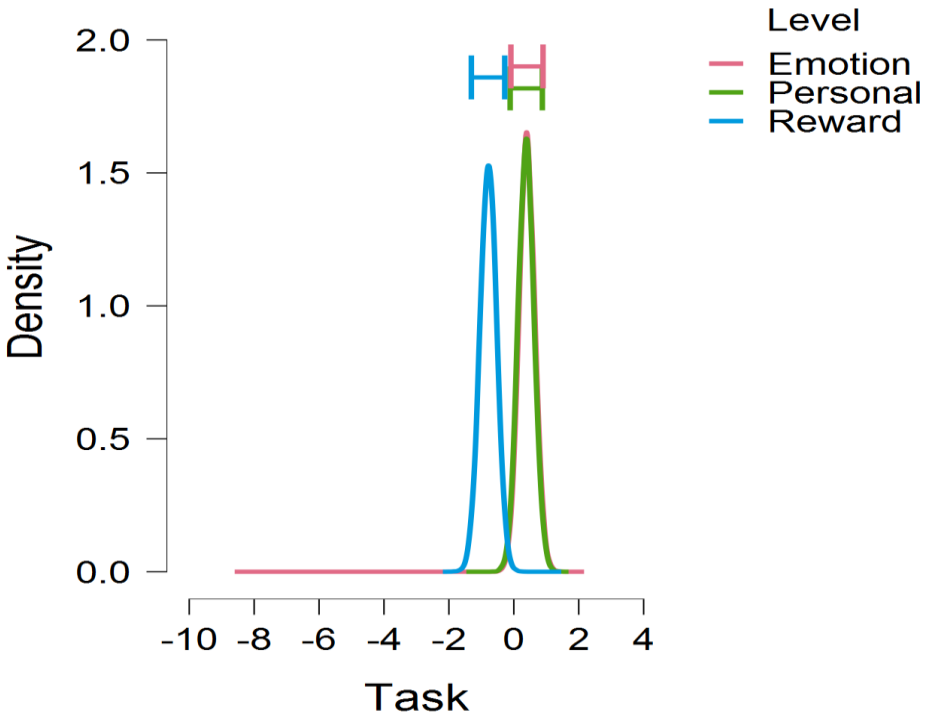

Figure 40a: Average posterior distribution for Task (Personal, Reward and Emotion) for mean posterior P2 amplitude. This figure demonstrates that there is a distinction between posterior distributions for Reward and Emotion task, each of them being compared to posterior distribution for self. i.e. Posterior distributions for personal task was used as a reference, thus indicating that there is a significant difference in the posterior distribution for Task. Because there was a distinction between the posterior distributions for Task, Post-Hoc comparison was conducted within the Bayesian framework (for Post-Hoc comparisons between the posterior distribution for Hemisphere for mean amplitude of posterior P2 see Table 6a).

Table 6a

Post-Hoc comparisons for posterior distribution for Task (Personal,Reward,Emotion) for mean amplitude of posterior P2.

		Prior Odds	Posterior Odds	$BF_{10, U}$	error %
Personal	Reward	0.587	7.473	12.722	2.454e -4
	Emotion	0.587	0.103	0.175	5.908e -6
Reward	Emotion	0.587	2.975	5.065	5.058e -4

Note. The posterior odds have been corrected for multiple testing byfixing to 0.5 the prior probability that the null hypothesis holds across all comparisons (Westfall, Johnson, & Utts, 1997). Individual comparisons are based on the default t-test with a Cauchy (0, r = 1/sqrt(2)) prior. The "U" in the Bayes factor denotes that it is uncorrected.

The results from the Post-Hoc comparisons between Personal vs Reward indicates posterior odds of 7.47 against the null hypothesis and comparisons between Reward vs Emotion indicates posterior odds of 2.98 against the null hypothesis which demonstrates evidence in favour of the alternative hypothesis (i.e., that there is a difference in mean amplitude of posterior P2 between the Tasks).

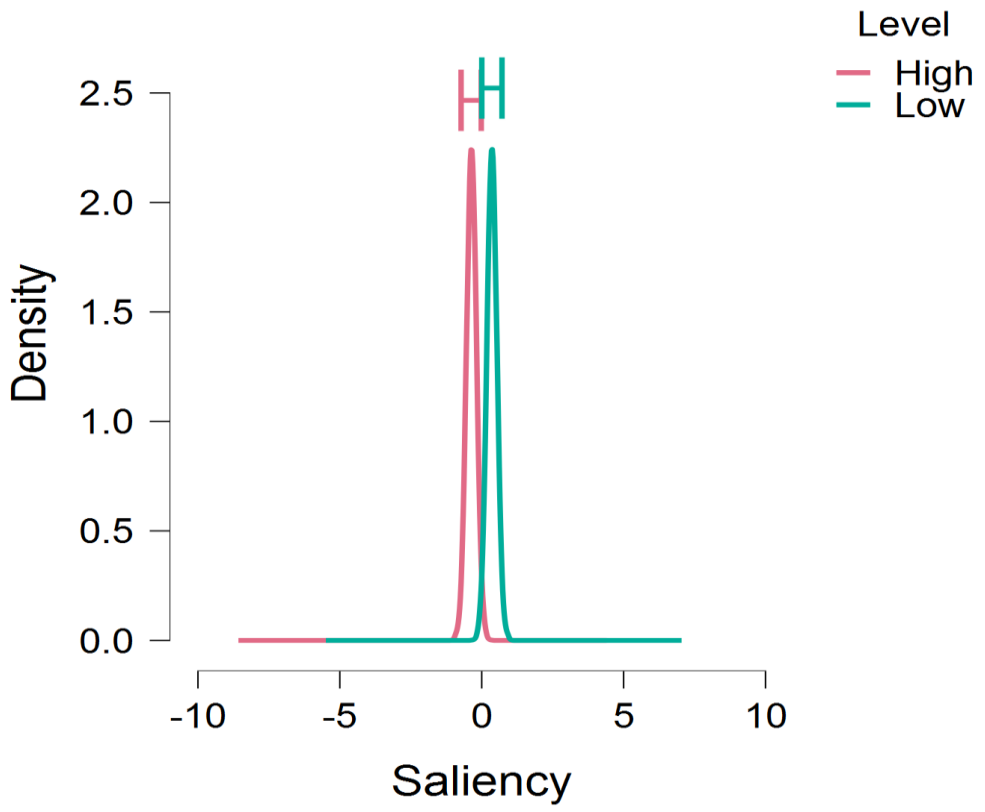

Figure 41a: Average posterior distribution for Saliency (High/Low) for mean posterior P2 amplitude. This figure demonstrates that there is a distinction between posterior distributions for Saliency, thus indicating that there is a significant difference in the posterior distribution for Saliency. Because there was a distinction between the posterior distributions for Task, Post-Hoc comparison was conducted within the Bayesian framework (for Post-Hoc comparisons between the posterior distribution for Hemisphere for mean amplitude of posterior P2 see Table 7a).

Table 7a

Post-Hoc comparisons for posterior distribution for Saliency (High/Low) for mean amplitude of posterior P2.

		Prior Odds	Posterior Odds	$BF_{10, U}$	error %
High	Low	1.000	2.510	2.510	1.179e -7

Note. The posterior odds have been corrected for multiple testing by fixing to 0.5 the prior probability that the null hypothesis holds across all comparisons (Westfall, Johnson, & Utts, 1997). Individual comparisons are based on the default t-test with a Cauchy (0, r = 1/sqrt (2)) prior. The "U" in the Bayes factor denotes that it is uncorrected.

The results from the Post-Hoc comparisons between High vs Low indicates posterior odds of 2.51 against the null hypothesis and which demonstrates evidence in favour of the alternative hypothesis (i.e., that there is a difference in mean amplitude of posterior P2 between High and Low saliency).

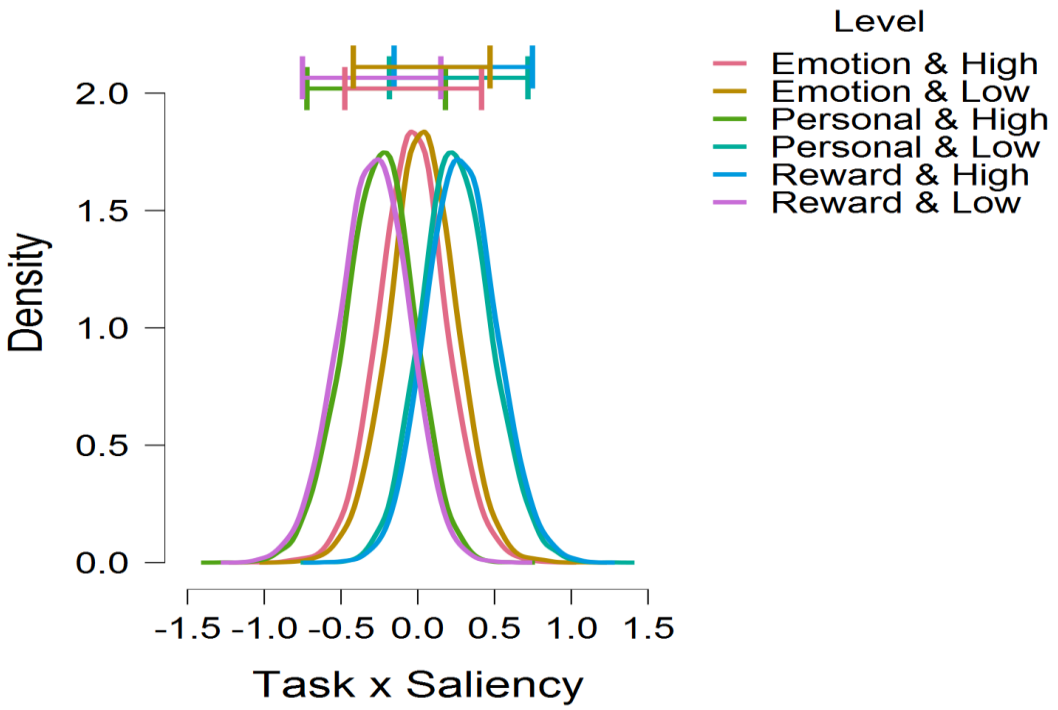

Figure 42a: Average posterior distribution for Task (Personal, Reward and Emotion) and Saliency Level (High/ Low) for mean amplitude of posterior P2. This figure demonstrates that there is mostly an overlap between posterior distributions for Task and Saliency thus indicating that there is no significant difference in the posterior distribution for the interaction between Task and Saliency.

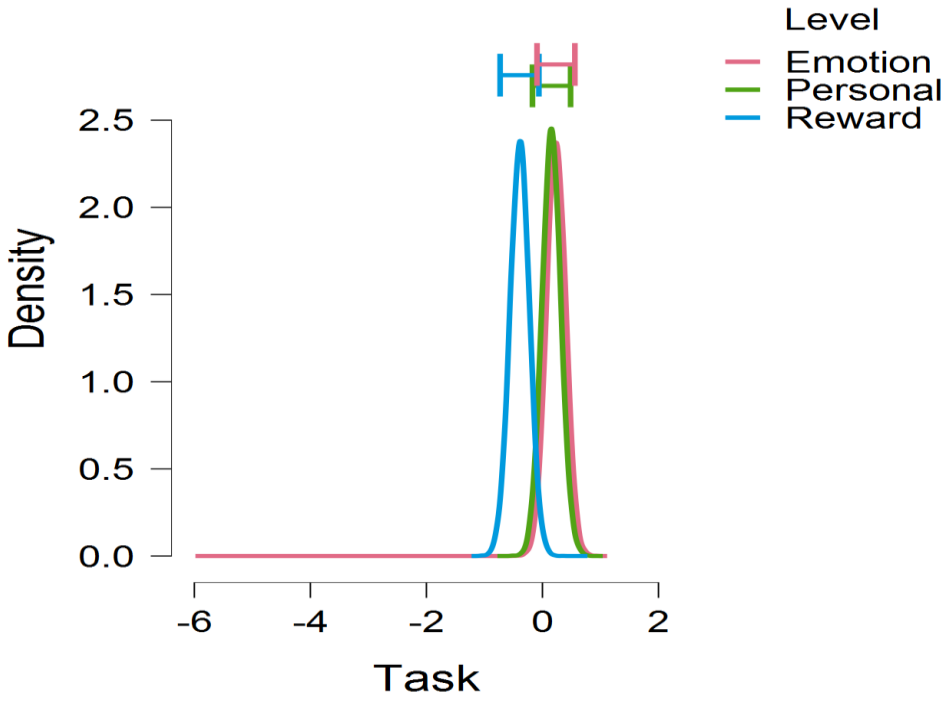

Figure 43a: Average posterior distribution for Task (Personal, Reward and Emotion) for mean posterior N2 amplitude. This figure demonstrates that there is a distinction between posterior distributions for the Reward task compared to the Personal and Emotion task, thus indicating that there is a significant difference in the posterior distribution for Task. Because there was a distinction between the posterior distributions for Task, Post-Hoc comparison was conducted within the Bayesian framework (for Post-Hoc comparisons between the posterior distribution for Task for mean amplitude of posterior N2 see Table 8a).

Table.8a

Post-Hoc comparisons for posterior distribution for Task (Personal,Reward,Emotion) for mean amplitude of posterior N2.

		Prior Odds	Posterior Odds	$BF_{10, U}$	error %
Personal	Reward	0.587	0.805	1.370	2.329e -6
	Emotion	0.587	0.080	0.137	6.940e -6
Reward	Emotion	0.587	1.669	2.842	1.511e -6

Note. The posterior odds have been corrected for multiple testing by fixing to 0.5 the prior probability that the null hypothesis holds across all comparisons (Westfall, Johnson, & Utts, 1997). Individual comparisons are based on the default t-test with a Cauchy (0, r = 1/sqrt (2)) prior. The "U" in the Bayes factor denotes that it is uncorrected.

The results from the Post-Hoc comparisons of Personal vs reward, Reward vs Emotion and Personal vs Emotion indicates strong evidence in favour of the null hypothesis and demonstrates that there is no evidence that the differences between personal- reward- and emotion-tasks supports the alternative hypothesis (i.e., that there is a difference in mean amplitude of posterior N2 between the Tasks).

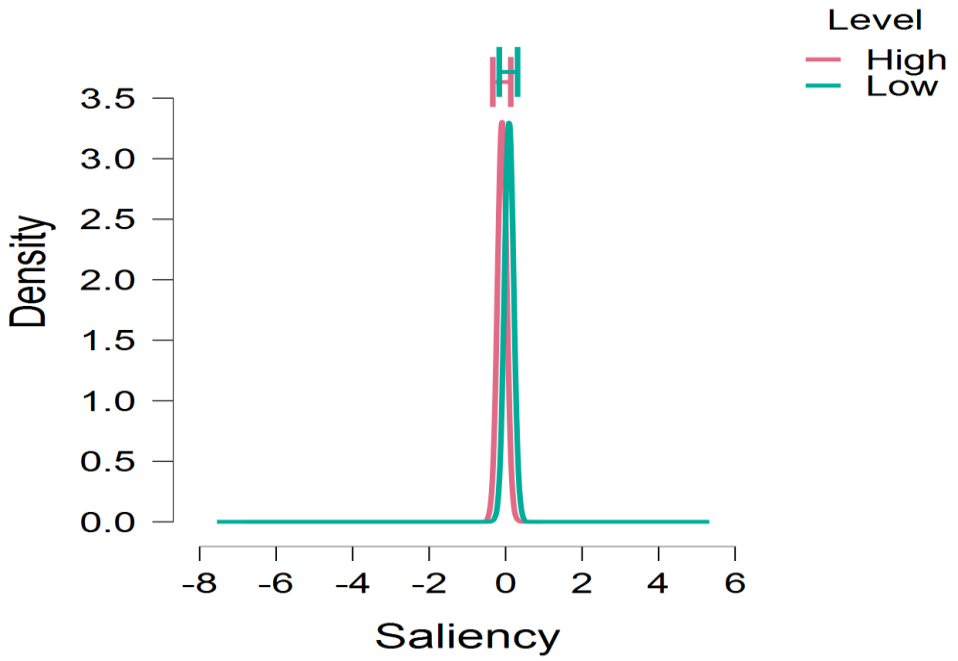

Figure 44a: Average posterior distribution for Saliency (High/Low) for mean posterior N2 amplitude. This figure demonstrates that there is an overlap in posterior distributions for Saliency, thus indicating that there is no significant difference in the posterior distribution for Saliency.

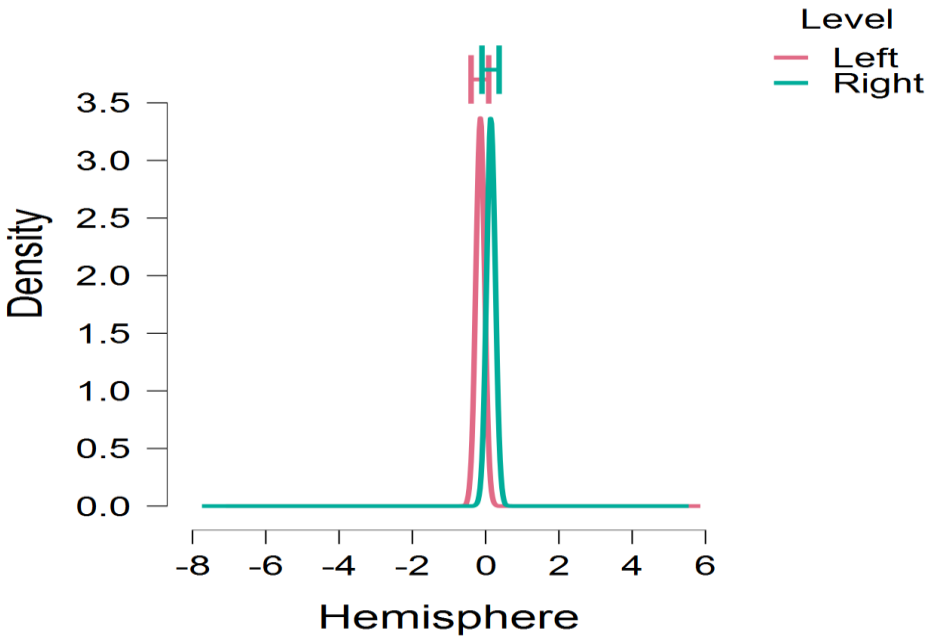

Figure 45a. Average posterior distribution for Hemisphere (Left/Right) for mean posterior N2 amplitude. This figure demonstrates that there is an overlap in posterior distributions for Hemisphere, thus indicating that there is no significant difference in the posterior distribution for Hemisphere.

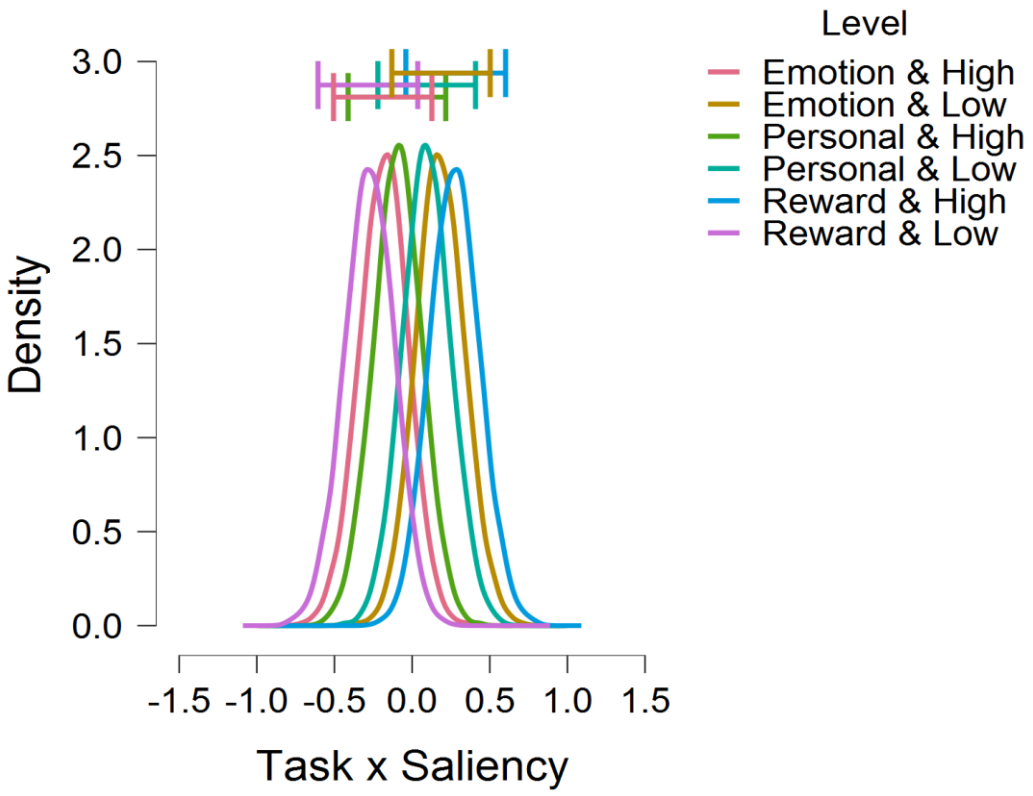

Figure 46a: Average posterior distribution for Task (Personal, Reward and Emotion) and Saliency Level (High/Low) for mean amplitude of posterior N2. This figure demonstrates that there is mostly an overlap between posterior distributions for Task and Saliency thus indicating that there is no significant difference in the posterior distribution for the interaction between Task and Saliency.

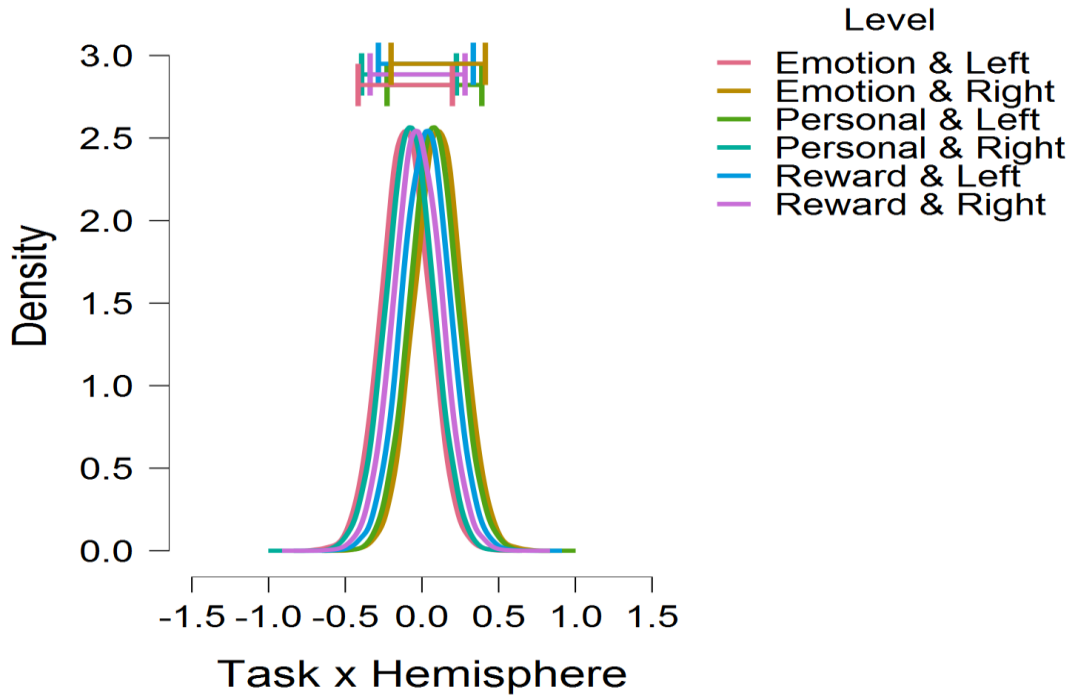

Figure 47a: Average posterior distribution for Task (Personal, Reward and Emotion) and Hemisphere (Left/Right) for mean amplitude of posterior N2. This figure demonstrates that there is an overlap between posterior distributions for Task and Hemisphere thus indicating that there is no significant difference in the posterior distribution for the interaction between Task and Hemisphere.

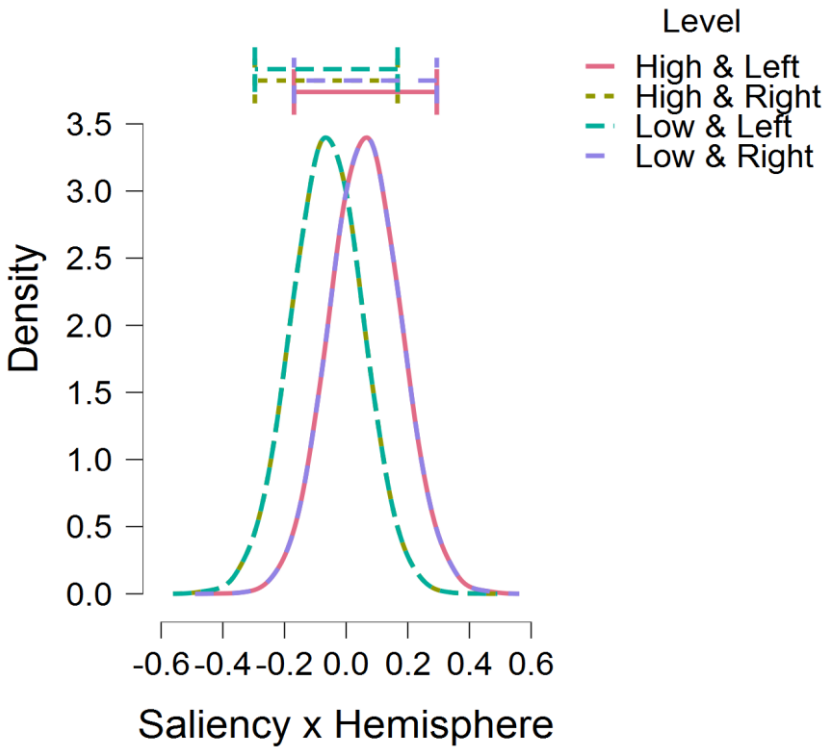

Figure 48a: Average posterior distribution for Saliency (High/Low) and Hemisphere (Left/Right) for mean amplitude of posterior N2. This figure demonstrates that there is an overlap between posterior distributions for Saliency and Hemisphere thus indicating that there is no significant difference in the posterior distribution for the interaction between Saliency and Hemisphere.

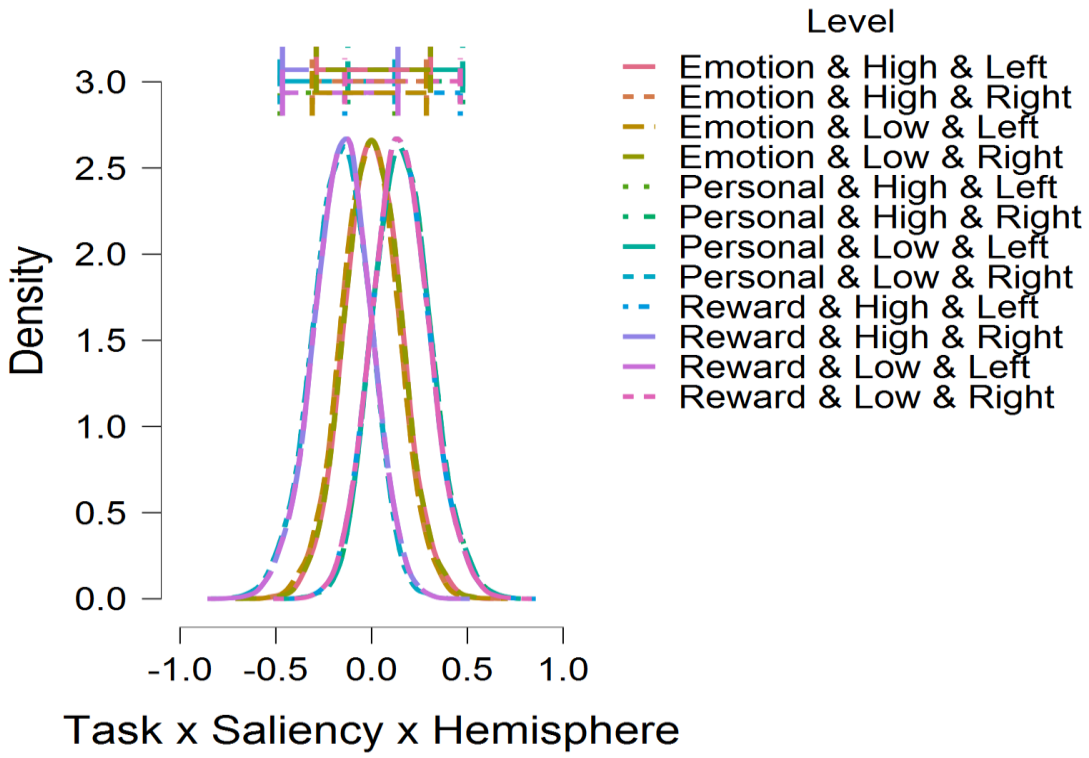

Figure 49a: Average posterior distribution for Task (Personal, Reward, Emotion), Saliency (High/Low) and Hemisphere (Left/Right) for mean amplitude of posterior N2. This figure demonstrates that there is an overlap between posterior distributions for Task, Saliency and Hemisphere thus indicating that there is no significant difference in the posterior distribution for the interaction between Task, Saliency and Hemisphere.

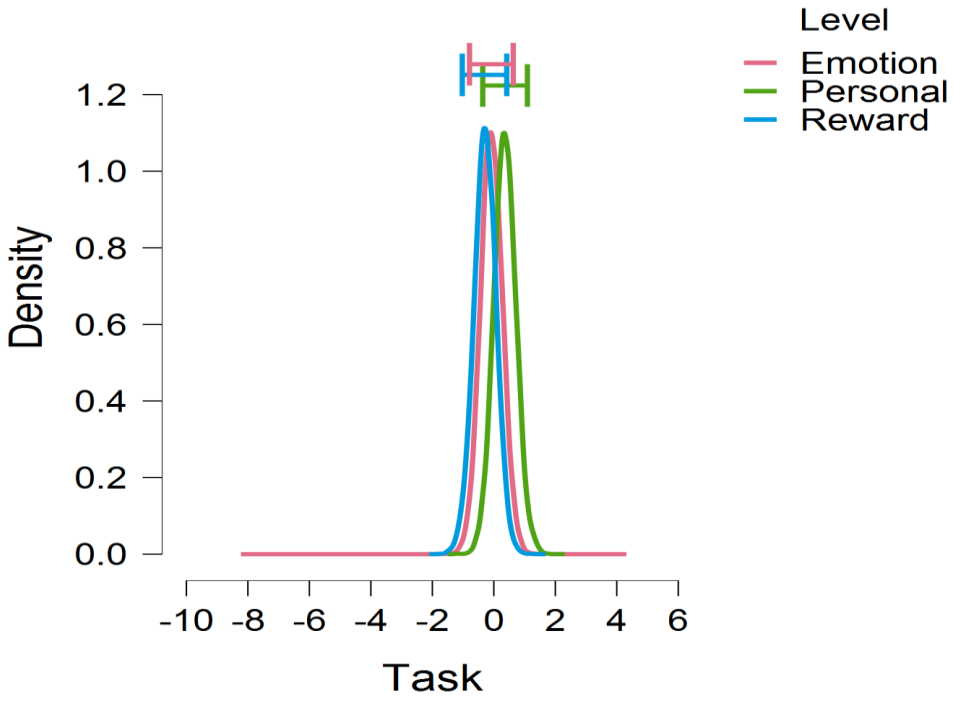

Figure 50a: Average posterior distribution for Task (Personal, Reward and Emotion) for mean amplitude of P3. This figure demonstrates that there is an overlap between posterior distributions for Task thus indicating that there is no significant difference in the posterior distribution for Task for mean amplitude of P3.

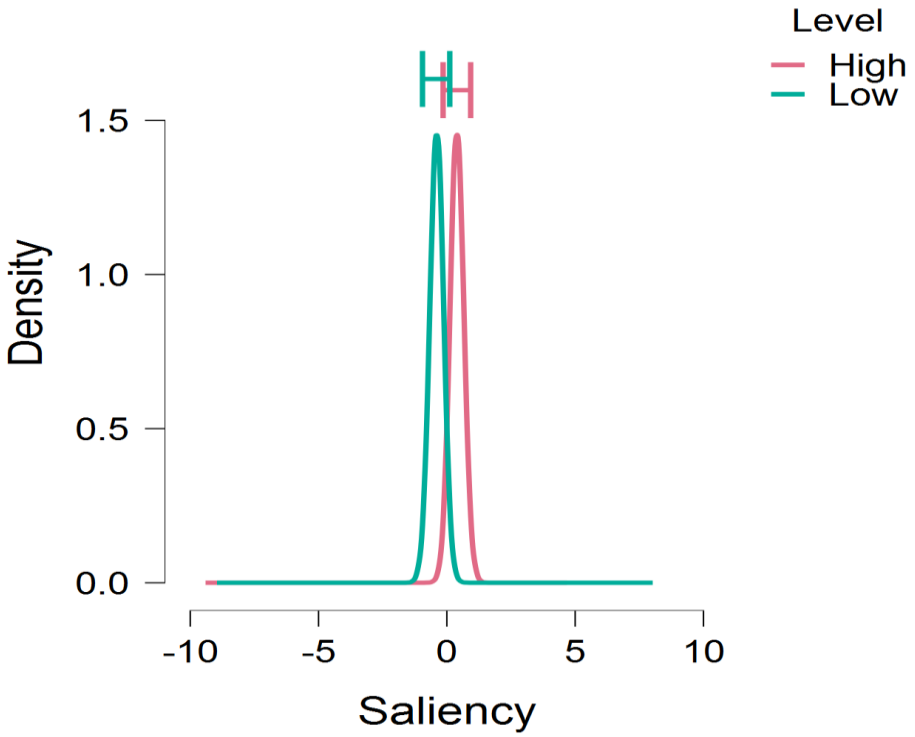

Figure 51a: Average posterior distribution for Saliency (High/Low) for mean amplitude of P3. This figure demonstrates that there is mostly an overlap between posterior distributions for Saliency thus indicating that there is no significant difference in the posterior distribution for Saliency for mean amplitude of P3.

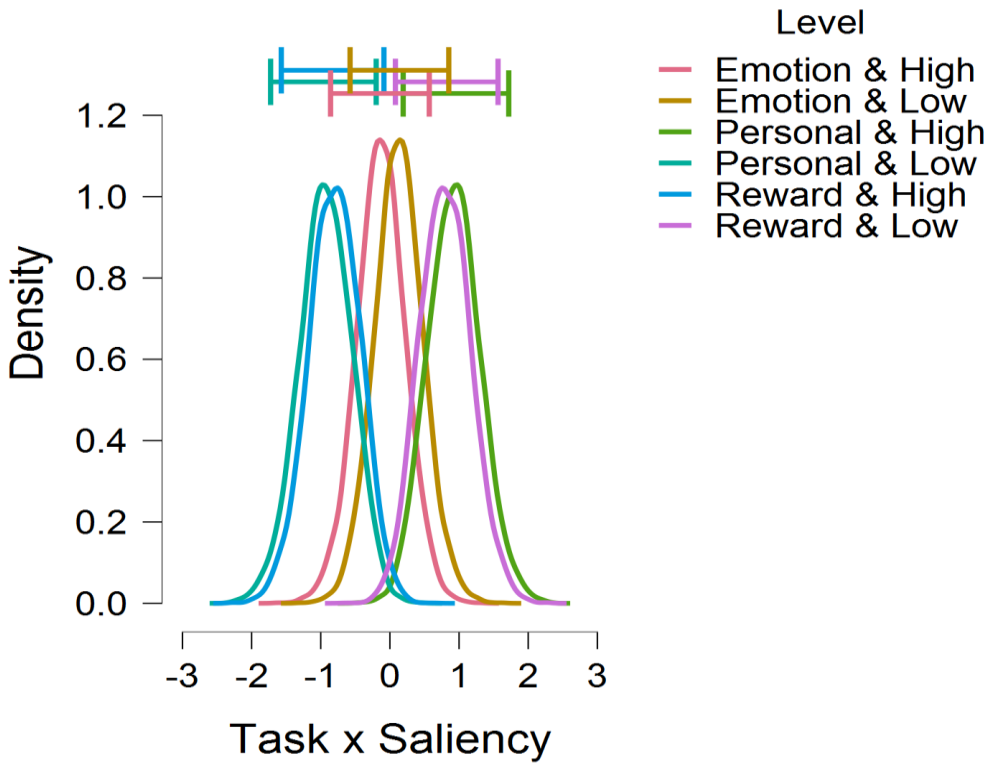

Figure 52a: Average posterior distribution for Task (Personal, Reward and Emotion) and Saliency Level (High/Low) for mean amplitude of P3. This figure demonstrates that there is a distinction between posterior distributions for Task and Saliency thus indicating that there is a significant difference in the posterior distribution for the interaction between Task and Saliency.

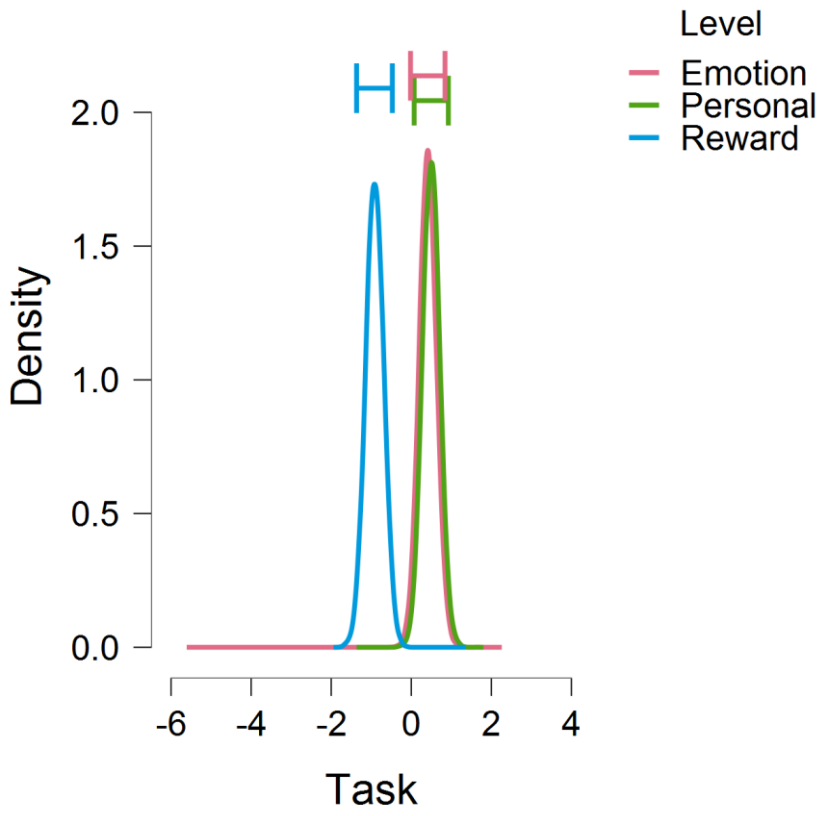

Figure 53a: Average posterior distribution for Task (Personal, Reward and Emotion) for mean amplitude of P1 effect. This figure demonstrates that there is a distinction between posterior distributions for the Reward task compared to the Personal and Emotion task, thus indicating that there is a significant difference in the posterior distribution for Task. Because there was a distinction between the posterior distributions for Task, Post-Hoc comparison was conducted within the Bayesian framework (for Post-Hoc comparisons between the posterior distribution for Task for mean amplitude of P1 effect see Table 9a).

Table 9a

Post-Hoc comparisons for posterior distribution for Task (Personal, Reward, Emotion) for mean amplitude of P1 effect.

		Prior Odds	Posterior Odds	$BF_{10, U}$	error %
Personal	Reward	0.587	17.942	30.545	3.586e -4
	Emotion	0.587	0.106	0.180	5.710e -6
Reward	Emotion	0.587	22.259	37.895	7.501e -8

Note. The posterior odds have been corrected for multiple testing by fixing to 0.5 the prior probability that the null hypothesis holds across all comparisons (Westfall, Johnson, & Utts, 1997). Individual comparisons are based on the default t-test with a Cauchy (0, r = 1/sqrt (2)) prior. The "U" in the Bayes factor denotes that it is uncorrected.

The results from the Post-Hoc comparisons between Personal vs Reward indicates posterior odds of 17.94 against the null hypothesis and comparisons between Reward vs Emotion indicates posterior odds of 22.26 against the null hypothesis which demonstrates evidence in favour of the alternative hypothesis (i.e., that there is a difference in mean amplitude of P1 effect between the Tasks).

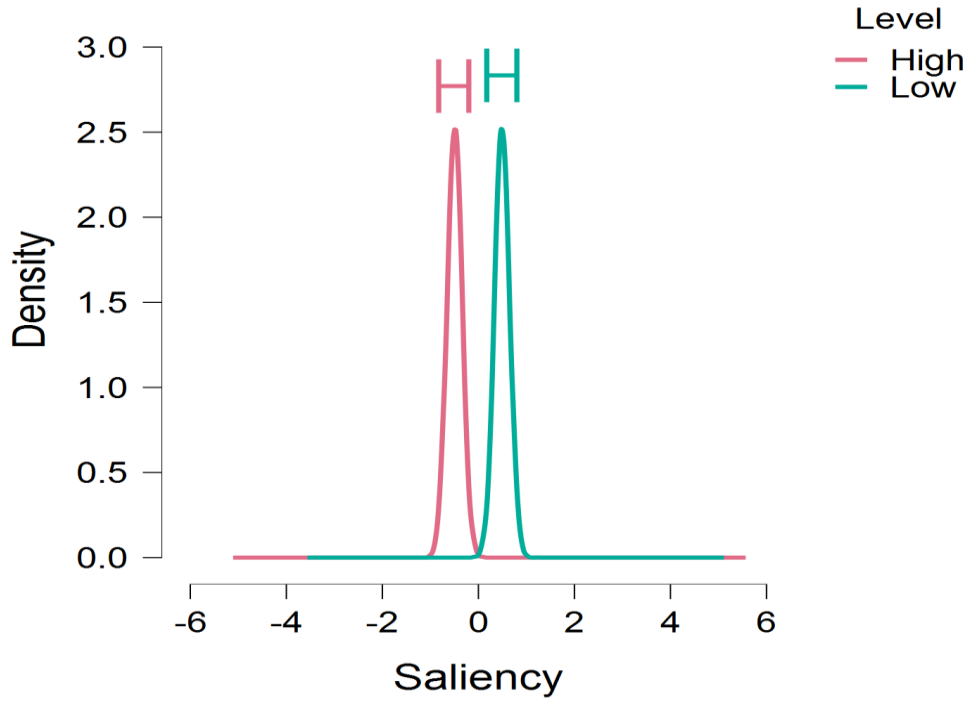

Figure 54a: Average posterior distribution for Saliency (High/Low) for mean amplitude of P1 effect. This figure demonstrates that there is a distinction between posterior distributions for Saliency thus indicating that there is a significant difference in the posterior distribution for Saliency for mean amplitude of P1 effect. Because there was a distinction between the posterior distributions for Saliency, Post-Hoc comparison was conducted within the Bayesian framework (for Post-Hoc comparisons between the posterior distribution for Saliency for mean amplitude of P1 effect see Table 10a).

Table 10a

Post-Hoc comparisons for posterior distribution for Saliency (High/Low) for mean amplitude of P1 effect.

		Prior Odds	Posterior Odds	$BF_{10, U}$	error %
High	Low	1.000	42.895	42.895	5.749e -8

Note. The posterior odds have been corrected for multiple testing by fixing to 0.5 the prior probability that the null hypothesis holds across all comparisons (Westfall, Johnson, & Utts, 1997). Individual comparisons are based on the default t-test with a Cauchy (0, r = 1/sqrt (2)) prior. The "U" in the Bayes factor denotes that it is uncorrected.

The results from the Post-Hoc comparisons between High vs Low Saliency indicates posterior odds of 42.9 against the null hypothesis and comparisons which demonstrates evidence in favour of the alternative hypothesis (i.e., that there is a difference in mean amplitude of P1 effect between Saliency).

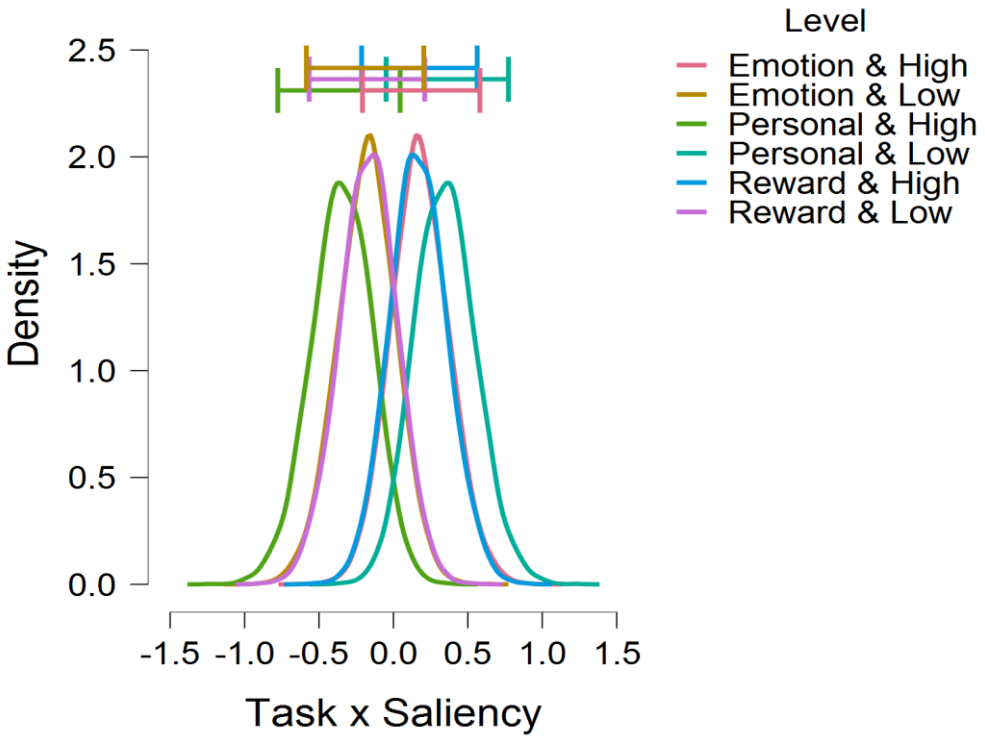

Figure 55a: Average posterior distribution for Task (Personal, Reward and Emotion) and Saliency Level (High/Low) for mean amplitude of P1 effect. This figure demonstrates that there is a distinction between posterior distributions for Task and Saliency thus indicating that there is a significant difference in the posterior distribution for the interaction between Task and Saliency.

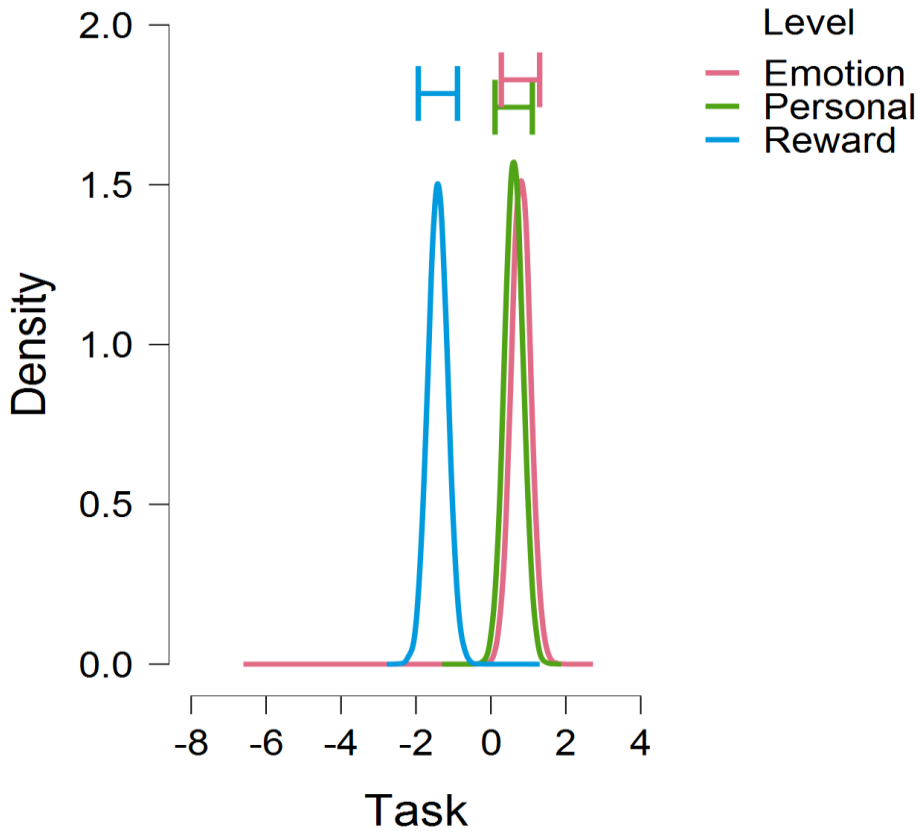

Figure 56a: Average posterior distribution for Task (Personal, Reward and Emotion) for mean amplitude of posterior P2 effect. This figure demonstrates that there is a distinction between posterior distributions for the Reward task compared to the Personal and Emotion task, thus indicating that there is a significant difference in the posterior distribution for Task. Because there was a distinction between the posterior distributions for Task, Post-Hoc comparison was conducted within the Bayesian framework (for Post-Hoc comparisons between the posterior distribution for Task for mean amplitude of posterior P2 effect see Table 11a).

Table 11a

Post-Hoc comparisons for posterior distribution for Task (Personal, Reward, Emotion) for mean amplitude of posterior P2 effect.

		Prior Odds	Posterior Odds	$BF_{10, U}$	error %
Personal	Reward	0.587	383.082	652.164	7.360e -9
	Emotion	0.587	0.112	0.191	5.296e -6
Reward	Emotion	0.587	2051.678	3492.807	3.384e -9

Note. The posterior odds have been corrected for multiple testing by fixing to 0.5 the prior probability that the null hypothesis holds across all comparisons (Westfall, Johnson, & Utts, 1997). Individual comparisons are based on the default t-test with a Cauchy (0, r = 1/sqrt (2)) prior. The "U" in the Bayes factor denotes that it is uncorrected.

The results from the Post-Hoc comparisons between Personal vs Reward indicates posterior odds of 383.08 against the null hypothesis and comparisons between Reward vs Emotion indicates posterior odds of 2051.68 against the null hypothesis which demonstrates evidence in favour of the alternative hypothesis (i.e., that there is a difference in mean amplitude of posterior P2 effect between the Tasks).

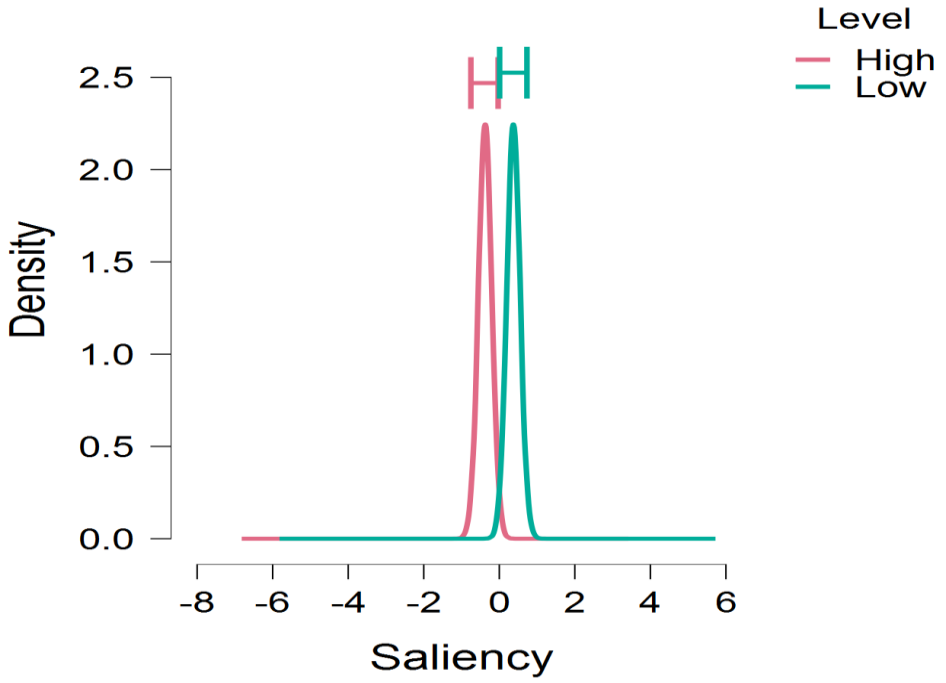

Figure 57a: Average posterior distribution for Saliency (High/Low) for mean amplitude of posterior P2 effect. This figure demonstrates that there is a distinction between posterior distributions for Saliency thus indicating that there is a significant difference in the posterior distribution for Saliency for mean amplitude of posterior P2 effect. Because there was a distinction between the posterior distributions for Saliency, Post-Hoc comparison was conducted within the Bayesian framework (for Post-Hoc comparisons between the posterior distribution for Saliency for mean amplitude of posterior P2 effect see Table 12a).

Table 12a

Post-Hoc comparisons for posterior distribution for Saliency (High/Low) for mean amplitude of posterior P2 effect.

		Prior Odds	Posterior Odds	$BF_{10, U}$	error %
High	Low	1.000	3.145	3.145	4.247e -8

Note. The posterior odds have been corrected for multiple testing by fixing to 0.5 the prior probability that the null hypothesis holds across all comparisons (Westfall, Johnson, & Utts, 1997). Individual comparisons are based on the default t-test with a Cauchy (0, r = 1/sqrt (2)) prior. The "U" in the Bayes factor denotes that it is uncorrected.

The results from the Post-Hoc comparisons between High vs Low Saliency indicates posterior odds of 3.15 against the null hypothesis and comparisons which demonstrates evidence in favour of the alternative hypothesis (i.e., that there is a difference in mean amplitude of posterior P2 effect between Saliency).

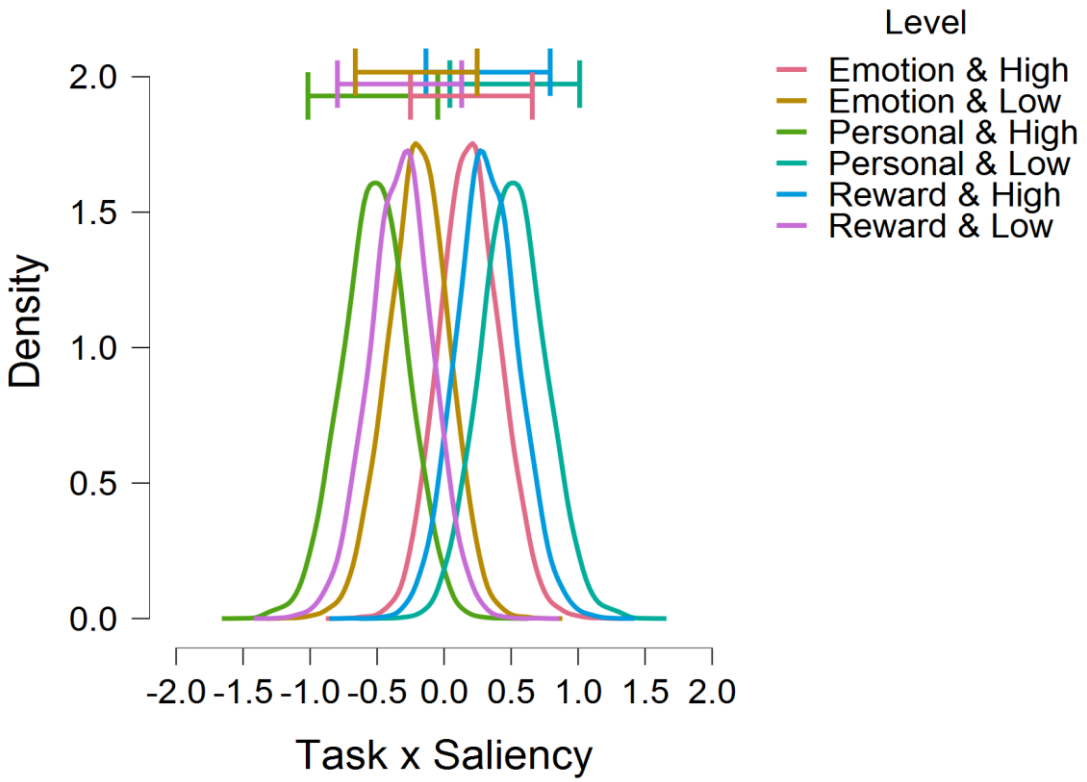

Figure 58a: Average posterior distribution for Task (Personal, Reward and Emotion) and Saliency Level (High/Low) for mean amplitude of posterior P2. This figure demonstrates that there is a distinction between posterior distributions for Task and Saliency thus indicating that there is a significant difference in the posterior distribution for the interaction between Task and Saliency.

Appendix. B

B1. List of arithmetic equations used for first filler task.

Maths worksheet 1 Participant number _____

Please complete the mathematical sums provided below (without a calculator).

1) 5 + 4 = ____	22) 11 – 5 = ____	43) 6 + 14 = ____
2) 10 + 10 = ____	23) 7 + 14 = ____	44) 2+ 18 = ____
3) 7 x 2 = ____	24) 9 x 3 = ____	45) 3 x 4 = ____
4) 5 + 5 = ____	25) 4 + 6 = ____	46) 12 + 7 = ____
5) 7 + 2 = ____	26) 1 x 3 = ____	47) 9 x 2 = ____
6) 10 + 9 = ____	27) 20 + 7 = ____	48) 15 – 7 = ____
7) 15 + 6 = ____	28) 16 – 7 = ____	49) 19 + 4 = ____
8) 7 x 4 = ____	29) 5 x 6 = ____	50) 6 + 8 = ____
9) 8 + 8 = ____	30) 3 + 17 = ____	51) 17 + 5 = ____
10) 16 – 15 = ____	31) 9 – 4 = ____	52) 7 – 3 = ____
11) 7 + 9 = ____	32) 6 x 3 = ____	53) 10 x 3 = ____
12) 2 x 10 = ____	33) 10 + 12 = ____	54) 5 + 9 = ____
13) 5 + 15 = ____	34) 4 + 17 = ____	55) 4 x 3 = ____
14) 9 – 9 = ____	35) 14 – 9 = ____	56) 11 – 4 = ____
15) 18 + 8 = ____	36) 7 + 2 = ____	57) 12 + 14 =____
16) 7 x 6 = ____	37) 14 – 4 = ____	58) 8 x 2 = ____
17) 8 + 14 = ____	38) 4 x 4 = ____	59) 11 + 5 = ____
18) 11 – 6 = ____	39) 8 + 10 = ____	60) 4 + 16 = ____
19) 14 + 3 = ____	40) 5 + 4 = ____	61) 13 – 3 = ____
20) 2 + 19 = ____	41) 6 x 2 = ____	62) 7 x 10 = ____
21) 22 – 17 = ____	42) 10 x 8 = ____	63) 28 – 12 = ____

64) 22- 7 = ____

65) 11 + 3 = ____

66) 8 – 7 = ____

67) 11 + 10 = ____

68) 9 x 6 = ____

69) 18 – 7 = ____

70) 7 x 3 = ____

71) 6 + 6 = ____

72) 14 – 8 = ____

73) 20 + 7 = ____

74) 5 x 3 = ____

75) 18 + 6 = ____

76) 10 – 8 = ____

77) 2 + 11 = ____

78) 14 – 6 = ____

79) 7 x 7 = ____

80) 18 + 3 = ____

81) 4 x 6 = ____

82) 12 – 6 = ____

83) 4 + 7 = ____

84) 17 + 6 = ____

85) 8 x 7 = ____

86) 10 – 4 = ____

87) 6 + 3 = ____

88) 21 – 8 = ____

89) 5 x 2 = ____

90) 2 x 7 = ____

91) 9 – 3 = ____

92) 11 + 11 = ____

93) 9 x 4 = ____

94) 7 x 11 = ____

95) 8 – 2 = ____

96) 16 – 5 = ____

97) 11 x 3 = ____

98) 9 x 5 = ____

99) 8 -6 = ____

100) 6 x 10 = ____

101) 18 + 6 = ____

102) 8 x 10 = ____

103) 7 x 9 = ____

104) 9 x 9 = ____

105) 15 + 7 = ____

106) 6 x 8 = ____

107) 17+ 14 = ____

108) 5 x 4 = ____

109) 12 – 4 = ____

110) 13 + 16 = ____

111) 7 x 5 = ____

112) 4 + 14 = ____

113) 19 – 11 = ____

114) 4 x 5 = ____

115) 9 + 9 = ____

116) 18 – 10 = ____

117) 24 + 13 = ____

118) 2 x 2 = ____

119) 13 – 7 = ____

120) 12 + 12 = ____

B2. List of arithmetic equations used for second filler task.

Maths worksheet 2 Participant number _____

Please complete the mathematical sums provided below (without a calculator).

1) 25 x 2 = ____	22) 15 – 9 = ____	43) 20 + 20 = ____
2) 17 + 9 = ____	23) 3 x 5 = ____	44) 12 x 3 = ____
3) 5 x 10 = ____	24) 19 – 6 = ____	45) 18 +11 = ____
4) 18 – 3 = ____	25) 6 x 7 = ____	46) 10 – 6 = ____
5) 8 x 8 = ____	26) 17 + 24 = ____	47) 3 x 3 = ____
6) 6 x 5 = ____	27) 20 x 3 = ____	48) 19 – 9 = ____
7) 10 + 17 = ____	28) 11 – 7 = ____	49) 11 + 6 = ____
8) 26 – 4 = ____	29) 14 + 15 = ____	50) 10 x 4 = ____
9) 5 x 7 = ____	30) 3 x 7 = ____	51) 17 + 17= ____
10) 19 – 7 = ____	31) 8 x 5 = ____	52) 8 – 3 = ____
11) 15 x 3 = ____	32) 16 + 12 = ____	53) 12 x 2 = ____
12) 6 x 6 = ____	33) 17 – 13 = ____	54) 8 + 7 = ____
13) 11 + 17 = ____	34) 10 x 7 = ____	55) 13 – 8 = ____
14) 27 – 8 = ____	35) 19 + 9 = ____	56) 8 x 3 = ____
15) 4 x 8 = ____	36) 9 – 2 = ____	57) 5 x 5 = ____
16) 16 – 2 = ____	37) 15 + 9 = ____	58) 27 – 16 = ____
17) 3 x 9 = ____	38) 9 x 7 = ____	59) 10 + 8 = ____
18) 22 – 12 = ____	39) 17 – 15 = ____	60) 11 + 4 = ____
19) 18 + 7 = ____	40) 11 x 4 = ____	61) 3 x 8 = ____
20) 8 x 6 = ____	41) 3 x 6 = ____	62) 4 + 4 = ____
21) 20 – 15 = ____	42) 29 + 5 = ____	63) 20 – 10 = ____

64) 6+ 5 = ____

65) 15 – 14 = ____

66) 9 x 10 = ____

67) 10 + 19 = ____

68) 4 x 9 = ____

69) 29 – 11 = ____

70) 13 + 13 = ____

71) 2 x 8 = ____

72) 17+ 11 = ____

73) 10 – 2 = ____

74) 19 + 6 = ____

75) 17 – 7 = ____

76) 5 x 11 = ____

77) 2 x 3 = ____

78) 14 + 8 = ____

79) 9 x 8 = ____

80) 24 – 12 = ____

81) 7 x 8 = ____

82) 9 + 7 = ____

83) 3 + 7 = ____

84) 17 + 7 = ____

85) 8 x 9 = ____

86) 10 + 4 = ____

87) 6 + 4 = ____

88) 11 – 8 = ____

89) 11 x 2 = ____

90) 4 x 7 = ____

91) 9 – 5 = ____

92) 21 + 11 = ____

93) 10 x 4 = ____

94) 6 x 11 = ____

95) 8 – 4 = ____

96) 16 – 6 = ____

97) 10 x 5 = ____

98) 9 + 5 = ____

99) 7 -6 = ____

100) 6 + 10 = ____

101) 18 – 6 = ____

102) 4 x 10 = ____

103) 7 + 8 = ____

104) 9 – 9 = ____

105) 14 + 7 = ____

106) 16 + 6 = ____

107) 17– 14 = ____

108) 5 x 8 = ____

109) 4 – 4 = ____

110) 12 + 13 = ____

111) 3 x 10 = ____

112) 14 x 2 = ____

113) 19 – 5 = ____

114) 4 x 11 = ____

115) 9 + 9 = ____

116) 28 – 10 = ____

117) 24 + 23 = ____

118) 2 x 4 = ____

119) 13 – 5 = ____

120) 11 + 12 = ____